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GREEN BEADS WITH RETICELLA DECORATION OF THE 8TH CENTURY BC IN ITALY – ON THE TYPE AND CHEMICAL COMPOSITION OF AN UNUSUAL FORM

BRIEF INTRODUCTION TO THE ISSUE

In general, the knowledge and presentation in the literature of glass beads of the first half of the 1st millennium BC are still very limited. Therefore, a particular bead form will be presented here, which so far is only known from a few specimens. However, it is special in its appearance in the context of the 8th century BC and for which some results from instrumental analytical chemistry are now available.

After the extensive Final Bronze Age glass bead production in the Veneto [1], it is difficult to understand the appearance of Early Iron Age glass beads. Completely different in colour, decorative techniques and glass composition from the older productions, their origin is thought on the one hand to be imports from the Aegean or even from the Levant, but on the other hand a production on the Italian Peninsula is not excluded. The locations of the melting of the raw glass are also unknown, and the different »types« of raw glass – so-called HMG and LMG (High/Low Magnesium Glass; discussed below), both occurring in the 9th–7th centuries BC – make it clear that the glass beads cannot be traced back to a single source. The evidence of different techniques of raw glass melting (Purowski et al. 2012) and the assumption of a European production (Conte et al. 2018, 513–514) illustrate that the situation is rather complex [2]. The earliest appearances in the Iron Age are black beads, both small and undecorated as well as large decorated forms. At the same time, however, a few translucent, weakly coloured beads can be found, which are compositionally and aesthetically completely different. Final Bronze Age beads were also used for a long time and were found as grave goods, as proven by typology and chemical analyses (Yatsuk et al. 2023; Koch in print). While imported forms are more common in Southern and Central Italy, in the Emilia-Romagna region glass was already being processed into spindle whorls and large beads used to decorate fibulae bows (*Glasbügelfibeln*) in the last third of the 8th century BC. First scientific investigations also point to a local raw glass production and the core technique can be related to beads from Slovenia and Croatia (Purowski et al. 2016; Koch 2020) – so different situations can be found depending on the region in Italy.

The classification of Early Iron Age beads is often still unsatisfactory on the basis of previously published finds, which are mostly presented as drawings. For the early 1st millennium BC, few glass colours and decoration techniques can be expected, but, in combination with bead shape and size, there is a wide range of variation, which should actually include glass chemistry as a classification criterion. A truly objective analysis requires that each bead form be examined separately and each glass type or colour be examined individually. With the much improved possibilities of publishing true-to-scale colour photographs, the classifications become better and only possible through these comparisons (e. g. Bracci 2007; Koch 2022). In this way, similarities and differences between the various find regions or among individual sites can be established.

The green beads with dark and yellow decoration presented here come mainly from *Latium Vetus* and nearby Sermoneta, with a few comparable finds from Etruria and Terni, today Umbria (see **lists 1–2**). How-

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Fig. 1 Spiral eye beads. – **a** Osteria dell'Osa 10 (**list 1**, A1; PG122). – **b** weathered spiral eye bead Osteria dell'Osa 99 (**list 1**, A2); decolouration of matrix glass in the photo on the right, white patina on the eyes. – **c** spiral eye bead Sermoneta-Caracupa 91 (**list 1**, A3; PG166); different eye forms can be seen. – **d** spiral eye bead Terni, S. Agnese, Acciaierie with only two incomplete eyes (**list 1**, A4; PG160). – (Photos L. C. Koch; a. c–d with kind permission of the © Museo delle Civiltà, Rome; b with kind permission of the Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma SSABAP-RM). – Scale 2:1.

ever, it is to be anticipated that upon further inquiry of other find complexes additional examples will turn up, even if they are not to be found among the material from Emilia-Romagna studied so far or the published beads from Campania.

CLASSIFICATION AND PRODUCTION TECHNIQUE

As mentioned above, the beads are characterised by their unusual colouring and a special decoration technique in the context of 8th- and early 7th- century BC Italy: a decoration consisting of yellow and dark, probably brown glass was applied to a green, opaque matrix glass. There are two different shapes: spherical-flattened beads of about 1 cm in diameter with two or three spiral eyes (**fig. 1**) and somewhat smaller beads of a different basic shape with an applied, dichromatic decorative thread (**fig. 2**) (»perle a sfera schiacciata verdi con occhio a spirale giallo-scuro e perle verdi di diversa forma con decorazione orizzontale a reticella semplice giallo-scuro« – »grüne gedrückt-kugelige Perlen mit gelb-braunen Spiralaugen und Perlen unterschiedlicher Form mit horizontalem einfachem, gelb-braunem Reticellafaden«). The green hue, a single example also in **figure 3**, stands out among the many other contemporaneous, copper-coloured, rather tur-

Fig. 2 Green beads with Reticella decoration. – **a** Osteria dell'Osa 10 (**list 2**, L1; PG121); the decoration is lost, leaving a groove; bubbles are apparent on the surface and the inner matrix glass. – **b** Osteria dell'Osa 99 (**list 2**, L2). – **c** Sermoneta-Caracupa 8 (**list 2**, L3; PG165). – **d** Sermoneta-Caracupa 60 (**list 2**, L4). – **e** Vetulonia, Poggio alla Guardia grave VII I Circolo interrotto (excavation I. Falchi 1886) (**list 2**, L5). – (Photos L. C. Koch; a. c–d with kind permission of the © Museo delle Civiltà, Rome; b with kind permission of the SSABAP-RM, Rome; e with kind permission of the Museo Archeologico Nazionale di Firenze). – Scale 2:1.

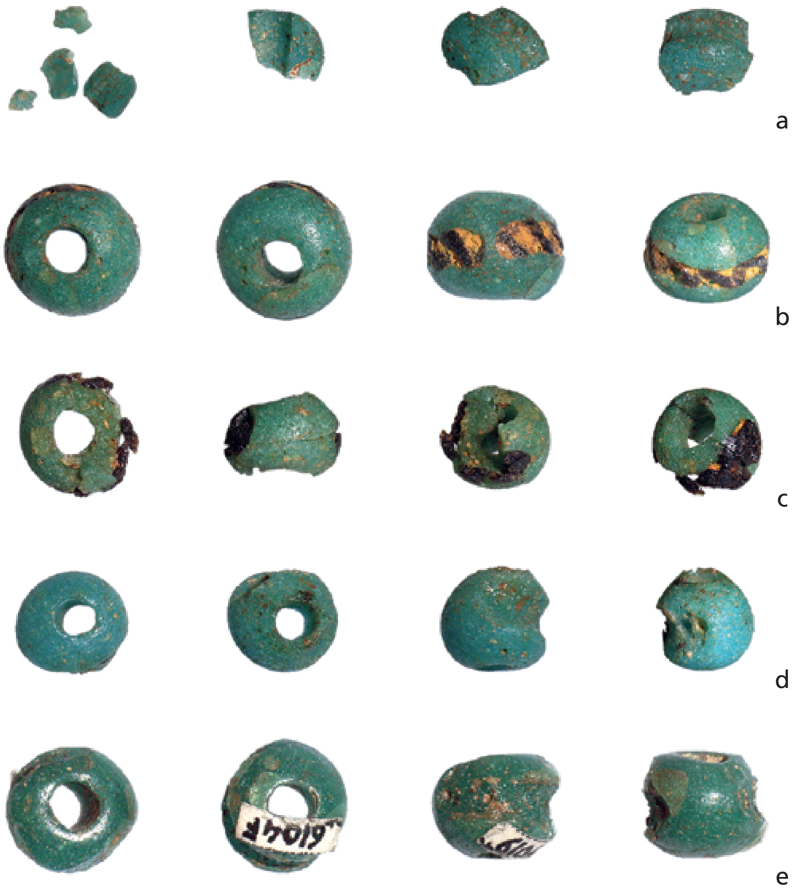

Fig. 3 Green bead from grave Osteria dell'Osa 82. The shape is irregular, the glass insufficiently fused and an inclusion can be seen. – (Photo L. C. Koch; with kind permission of the © Museo delle Civiltà, Rome). – Scale 2:1.

quoise beads, which are mostly translucent – although this translucency may be obscured by surface corrosion (colour illustration e. g. Yatsuk et al. 2023, fig. 2). The green glass has been opacified by a large amount of gas bubbles, which are readily visible to the naked eye. This is true of all the beads presented here, which is why it is assumed that the matrix glass can be traced back to the same source, i. e. a geographical region or perhaps even the same workshop.

The decoration of both types requires a separate preparation step, i. e. the melting together of yellow and dark glass, which is then processed further. For the stripe-decorated beads, an equal portion of yellow and dark glass is melted together, as two rods or two portions on a mandrel, then twisted and drawn out while still hot to form a two-coloured spiral thread (**fig. 4a**). This procedure was already used in Egypt and

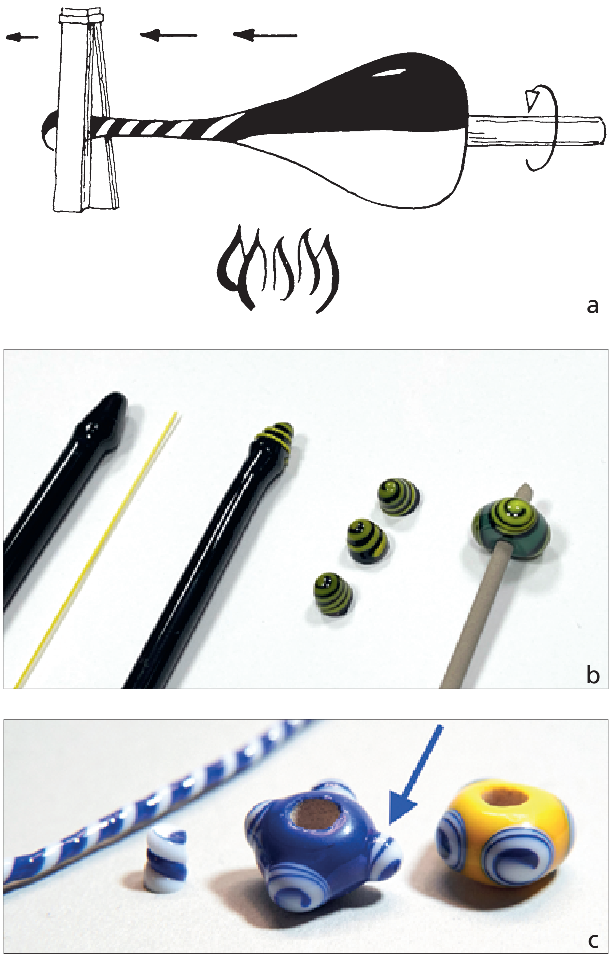

Fig. 4 **a** Schematic representation of the production of a simple Reticella rod. – **b** modern reproduction of the green spiral eye beads by Christian Rupp. – **c** modern reproduction of spiral eyes with a prefabricated Reticella rod by Mareike Grunert. The attached, oblique element is marked with an arrow (cf. **fig. 1a**). – (a after Stern/Schlick-Nolte 1994, fig. 71; b photo Ch. Rupp; c photo M. Grunert).

Mesopotamia in the 2nd millennium BC to decorate vessels with dichromatic spiral threads (e. g. Schlick-Nolte 1968, pls III, 2–3; VIII, 21; X, 3. 8; XVI, 3–4. 6–7. 9; Stern/Schlick-Nolte 1994, 32–33 figs 8–9; Matsumara 2020, fig. 6) and can also be found in later times (e. g. Paynter et al. 2022). It could be described as a »simple« Reticella technique, defined and best known above all on Roman glass vessels, in which case, however, it was worked primarily with colourless and transparent glass (e. g. Lierke 1999, 23 fig. 40; 39–44 figs 79–89). This prefabricated spiral rod was reheated, placed around the green bead body and melted down – the bead still sticking on its mandrel and kept hot with regular rotation over a forced fire, whereby the decorative thread sinks in completely[3]. It was obviously avoided to let the ends of the decorative thread overlap, in order not to disturb the pattern (**fig. 2b** and also **fig. 2c–e**, beads with lost decoration). This creates a characteristic diagonal stripe decoration (cf. Koch 2011, 76 fig. 43).

In general, there are different procedures conceivable for the spiral eyes: One possibility is to use thin segments cut off from the cold rod. This procedure corresponds to the production of »mosaic glass«, as it is already well documented in Bronze and Iron Age vessel production in Mesopotamia or for the Roman »millefiori« vessels and Early Medieval beads (e. g. Stern/Schlick-Nolte 1994, 46 fig. 39; 55–65; Spaer 2001, 118–126; Lierke 2009, 19; Schmidt 2019, 37–39 with fig. 4.2; 43–45 with fig. 4.6–7 pls 1–4; Callmer 1997; Sode et al. 2022, 160–161 figs 1. 4). In this case a rod of decorative glass must have been made, which appears as a spiral eye in cross-section. For this, the two colours were melted on top of each other, flattened out to form a »sheet« and wound round a glass rod or mandrel (see Stern/Schlick-Nolte 1994, 58–59 figs 85–86; Spaer 2001, 50–52 fig. 18). Flat slices are then cut off from the drawn and cooled rod, which can then be melted into the bead body. Such a procedure would result in flat spiral eyes that are completely identical in number of turns and central colour – but this is not the case for the green beads presented here (e. g. **fig. 1c**).

An experimental production trial of our beads by Christian Rupp, who specializes in glass beads of the Viking Age[4], took a different approach in creating prefabricated elements: a portion of conical glass on a dark glass rod was coiled spirally from the base to the tip with yellow glass, melted and cut off with tongues when cooled down[5]. Three of these elements were fused into the bead body. The resulting bead closely resembles the archaeological models (**fig. 4b**). The dark base of a broken eye on the bead from Terni could be interpreted as the remains of a similar procedure (**list 1**, A4, **fig. 1d**). This means, however, that each eye had to be prepared separately and would explain why they can differ on the same bead.

Another possible method is to use a twisted bicoloured Reticella rod of the same kind as previously described and obviously used for the stripe-decorated beads (**fig. 2b**). Longer sections of the Reticella rod were attached to the hot bead's surface, they expand and become conical-flat when melted into the bead body, thus forming a spiral. The protruding spiral eyes of the bead from Osteria dell'Osa grave 10 (**list 1**, A1, **fig. 1a**) suggest an obliquely attached and insufficiently melted fragment of a twisted rod (cf. Beck 1928 [2006], 45 fig. A.10d, a Roman bead). Mareike Grunert[6], a specialist in the reproduction of prehistoric glass beads, has obtained good results with this method. Moreover, one of her beads with an incompletely fused reticella segment clearly resembles our example from Osteria dell'Osa (cf. **fig. 1a** with **fig. 4c**). Other methods described by Horace C. Beck (1928 [2006], 64–65) seem less plausible.

The application of prefabricated spiral decoration elements can also be observed on spiral eye beads of another bead class found in Greece in the 8th–6th century BC with a basic triangular shape (e.g. Lefkandi: Koch 2011, fig. 37, 1; Ephesus: Pulsinger 2001, 209–210 esp. notes 3 and 10 pl. 7, 2. 6. 9; Euboea: Schmid 2000/2001, 115–117). For both forms of decoration Beck (1928 [2006], 45 fig. 34b type A.10.b and figs 63–64) has described parallels from Egypt during the 18th–20th Dynasties, where, as is well known, prefabricated rods were used.

Regardless of this, these observations make it clear that the forming of the stripe-decorated beads and those with spiral eyes are two separate production processes, which is also indicated by the tendency to different sizes between the beads (**lists 1–2**), but maybe with the same kind of ready-made Reticella rods of decorative glass. With regard to the similarity of the glass and colour combination, their manufacture in the same workshop is quite conceivable. Unfortunately, results from the chemical elemental analyses are insufficient to draw definitive conclusions that the beads derive from the same batch made at the same time. Even if the decorative techniques had been known for a long time, we cannot assume a Bronze Age tradition. Rather, these are simple glass-working practices that were certainly »invented« several times. Nevertheless, they are something exceptional in Italy in the 8th century BC.

FIND CONTEXTS: CHRONOLOGY AND DISTRIBUTION

The source of Early Iron Age beads is almost exclusively graves from the rich necropolises of Italy between the 10th and 7th century BC. The collection of the Museo delle Civiltà in Rome (formerly Museo Preistorico Etnografico »Luigi Pigorini«)[7] includes grave contexts from all over Italy, but no complete necropolis. Investigations there make it possible to quickly gain an insight into different materials, but an archaeological evaluation that includes burial customs and social aspects is not possible. The focus here is on two necropolises: Sermoneta-Caracupa in the Lepini Mountains (Catalogue Rome 1976; most recently Virili 2017), and Osteria dell'Osa, not far from Rome, which was published and evaluated in its entirety in 1992 (Bietti Sestieri 1992a; 1992b; introduction to the site: Koch 2021a, 17–19). A large part of the glass beads from the latter cemetery could be studied at the Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma (SSABAP-RM)[8] in 2022 and 2023. Eleven other complexes with beads are exhibited in the Museo Nazionale Romano – Terme di Diocleziano. In two graves from Osteria dell'Osa both bead forms occur (graves 10 and 99 of phases IIIA and IIIB), so they can be considered to be contemporaneous. Both are women's graves, relatively rich, and the green beads formed together with other beads, pendants and fibulae a typical element of costume. For the reticella-stripe decorated beads, a more recent context is also indicated (**list 2**, L6: Narce, c. 2nd quarter of the 7th c. BC). However, chronological comparison between different regions of Italy is always subject to the problem of different absolute chronological systems, which, for example, place the beginning of the Iron Age in Northern Italy around 900 BC and in Latium some two generations earlier, in the middle of the 10th century BC (for literature see Koch 2021a, 18). Grave 91 at Sermoneta-Caracupa (**list 1**, A3) is also dated to the Lazio III phase, which corresponds largely to phase III of Osteria dell'Osa (cf. Pacciarelli 1999, fig. 15; 2001, fig. 38); similarly, grave Vetulonia, Poggio alla Guardia VII – the rich grave of a female with an imported Phoenician bronze bowl – is dated to the third quarter of the 8th century (**list 2**, L5). Depending on absolute chronological approaches, we can expect the appearance of green beads from the second half of the 8th century BC by the latest.

Spiral eye beads are also present in incompletely published necropolises of Latium such as La Rustica (Rome) and Crustumerium [9] (**list 1**, A5). In addition to the green bead from Vetulonia (**list 2**, L5), there may be other examples from Etruria, which unfortunately could not yet be verified: From Veii, Quattro Fontanili (grave QRbeta), a bead has survived whose redrawing is comparable to our Reticella-rod-decorated beads, but unfortunately lacks any description of colour and decoration (Notizie degli Scavi 1972, 377–378 fig. 122; reproduced in Koch 2011, fig. 43, 2 and 83F1). The grave is dated to Veio IIA, a phase considered to be partly overlapping or completely contemporaneous with Osteria dell'Osa IIIA (cf. chronological schemes in: Nizzo 2018, fig. 1; Pacciarelli 1999, fig. 15 and Pacciarelli 2001, fig. 38; Fulminante 2020, tab. 1). So chronologically, there is nothing to prevent this being a specimen of our bead forms. From Tarquinia, grave Selciatello Sopra 169 (phase Tarquinia IIA according to Hugh Hencken), the fragment of half a bead, obviously decorated with reticella, has survived. The description reads »yellow bead with silver stripes« (Hencken 1968, 144 fig. 132). However, if one looks at the weathered eye bead from grave Osteria dell'Osa 99 with its partially decoloured body and the patina formation of the decorative glass (**fig. 1b**), it is quite possible that it is a weathered green bead with yellow-dark decoration, especially since the dimensions of dm. c. 0.8 cm and h. c. 0.5 cm correspond (compare with **list 2**). The same could apply to an »ivory-coloured« bead with »gold-coloured« inlays from Tivoli (Rome) (Catalogue Rome 1976, 195 no. 62 pl. XLV, 9C.d). As is so often the case, only a personal examination can provide certainty. In addition to Central Italy, we can therefore probably expect our green beads to be found in Etruria as well.

PARALLELS AND QUESTIONS OF ORIGIN

In addition to the formal parallels from Egypt and Lefkandi (see above), attention should also be drawn to a bead in the collection of the British Museum in London. It comes from Kamiros (Rhodes), apparently without a more precise context and is probably to be attributed to the votive deposits of the sanctuary there (**list 1**, A6). Except for the matrix glass, which seems to be rather blue in colour, it corresponds closely to the spiral eye beads from Italy. Under the same number in London, there are two other, larger beads with spiral eyes. The colours are not clearly discernible, but the decoration is also light-dark on a blue or dark matrix glass. Another, 2 cm long barrel bead from Kamiros has a yellow-dark reticella thread turned around the bead body three times [10]. The decorative glass, especially the yellow, is clearly better preserved in the beads from Kamiros than in the beads from Italy – this can be an indication of a different glass formula or due to different post-depositional conditions.

These pieces could be an argument for a larger production of spiral eye beads on Rhodes or as imports in both finds regions from a common place of manufacture. If one considers the contemporaneous bird beads, which are also made of a HM-type glass (Conte et al. 2016, 419–420. 423; Koch in prep.), an import of the spiral and reticella beads from the Aegean, respectively from Rhodes to Italy also seems likely. Conversely, an Italian type of bead may also have found its way into the sanctuary of Rhodes, just as jewellery forms, especially amber, are found in Aegean sanctuaries in addition to weapons (e.g. Baitinger 2013; Naso 2013; 2016).

The results of the scientific trace element analysis now open up the possibility of seeing the green beads as a local Italian production – both the production of the raw glass and its colouring, as well as the shaping of the beads (see below). If this were the case, we might be looking at a local imitation of an imported model. The inconsistency of the spiral eyes and the variation in the shape of the stripe-decorated beads could be interpreted as an indication of the beadmaker's »uncertainty«. The undecorated and oblique green bead from Osteria dell'Osa grave 82 (phase IIIB; PG169, **fig. 3**) is proved to be made of a chemically analogous matrix glass. This, too, could be an indication of a local, perhaps experimental, manufacture in one and the same workshop. However, until larger, complete chemical records from Italy and Rhodes are compared, this can only be a preliminary result.

CHEMICAL ANALYSIS

Five beads of the types presented here were analysed: three beads with spiral eyes (Osteria dell'Osa grave 10 = PG122, Sermoneta-Caracupa grave 91 = PG166 and Terni-Acciaierie = PG160) and two beads with line decoration (Osteria dell'Osa grave 10 = PG121 and Sermoneta-Caracupa grave 8 = PG65). Due to the greenish colour, another bead was included for comparison (PG169; **fig. 3**); it also comes from Osteria dell'Osa, grave 82 of the local phase IIIB (Bietti Sestieri 1992a, 823–826) and is kept at the Museo delle Civiltà – »Luigi Pigorini« in Rome (inv. no. 109312).

The methods for the instrumental analytical characterisation utilised to study the beads or the fragments considered in this study can be roughly divided into compositional approaches (for which the final result is the quantity of the chemical elements in the glass), as well as morphological and structural approaches (that investigate the micro-morphology of the material, such as the presence of inclusions inside the glass matrix and atomic arrangement in glass). The compositional methods we used in this study are X-Ray Fluorescence (XRF) spectrometry and Laser Ablation Inductive Coupled Plasma Mass Spectrometry (LA-ICP-MS) (for more details see Yatsuk et al. 2023).

XRF used as a portable setup is an excellent method for the fast analysis of elements heavier than aluminium. Given proper calibration, it is possible to obtain the accurate elemental composition of the material for the elements that are present in concentrations above some tens of parts per million (ppm). The drawback of this method for glass (by using a portable instrumental setup) is the impossibility to obtain reliable quantitative information about the lighter elements, like sodium, magnesium and aluminium that play an important role in glass characterisation and can tell a lot about the raw materials used in its production. In this work, potassium could be determined only in the beads for which the concentration of this element was above 1 %.

LA-ICP-MS is another method for the elemental analysis of materials. It has much lower limits of detection than XRF and, therefore, can reliably quantify a large set of elements, even those that are present in trace quantities, maintaining the structural integrity of the object. The information on trace elements can be useful when attempting to establish the provenance of glass.

The micromorphological and structural methods of characterisation produce information on whether or not the glass is homogeneous and can give hints on how the atoms of elements are organised in the material. The ones used in this study are: optical microscopy, Fibre Optics Reflection Spectroscopy (FORS) and Raman spectroscopy. FORS provides information on how the colour is achieved. Some transition elements (Mn, Fe, Co, Cu), when occupying certain positions in the atomic network of glass, find themselves in coordination with oxygen atoms. In these positions, they absorb light of specific wavelengths in the visible range, determining the perceived colour of the glass. They are detected by measuring the trend of the absorption

sample ID	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	MnO	Fe_2O_3	CuO	Sb_2O_5	PbO
PG121g	20.18	3.30	2.46	63.97	1.99	5.60	0.16	0.028	1.05	0.64	0.013	0.014
PG122g	21.55	3.93	3.10	57.76	1.51	7.83	0.25	0.042	1.48	1.56	0.083	0.005
PG122y	19.68	4.07	3.11	55.30	1.75	9.29	0.25	0.037	1.44	0.19	0.529	3.476
PG122d	20.57	3.24	2.50	63.60	2.11	6.46	0.21	0.026	0.72	0.01	0.001	0.003

Tab. 1 LA-ICP-MS data on the amounts of the major and minor elements in the glass (expressed as oxides) in weight percent. g – green, y – yellow, d – dark.

of visible light. Raman spectroscopy has several uses in glass studies. The vitreous matrix usually consists of tetrahedra of silica, which feature characteristic bending and stretching vibrations of the silicon and oxygen atoms that are detected through Raman spectroscopy. Raman spectroscopy can also identify crystalline inclusions in the vitreous matrix. These can be interpreted as intentional additions for opacification, impurities of the raw materials or products of devitrification (rearrangement of the glassy structure into a crystalline one) and weathering. It can be used in micro setup directly on the surface of the unprepared beads and causes virtually no damage.

The six beads in this study were analysed with optical microscopy, FORS and XRF in the museum using portable equipment. PG121 and PG122, both the green matrix glass and the dark and yellow decorative glass, were analysed with Raman and LA-ICP-MS; a fragment of PG121 was also analysed with SEM-EDS without obtaining any additional information (Yatsuk et al. 2023, fig. 6) to the one obtained by LA-ICP-MS.

RESULTS (CHARACTERISATION OF GLASS)

The major elements' composition is provided by LA-ICP-MS data, which are only available for two beads of different decoration from the same grave (Osteria dell'Osa 10, PG122 and PG121, **figs 1a; 2a**). **Table 1** shows that the major constituents of this glass are silica (SiO_2), soda (Na_2O) and lime (CaO). At the same time, significant amounts of MgO, Al_2O_3 and K_2O are also present. The presence of magnesium (MgO) and potassium (K_2O) oxides in quantities above 1.5 % indicates the use of soda-rich plant ash, probably from halophytic plants, as a fluxing agent to lower the melting point of the silica-based glass batch (Rehren 2000). Such ash also contains significant amounts of calcium and, usually lower, aluminium levels (Tite et al. 2006). Glass prepared with this type of ash is called »High Magnesium Glass« (HMG) and is known from the Late Bronze Age period in Mesopotamia and Egypt from the middle of the 2nd millennium BC onwards as well as in later contexts (Mirti et al. 2008; Angelini 2011, 21; Henderson 2013, 88; Lončarić / Costa 2023, 3845–3846). We can expect that many other minor elements, such as Ti, Mn, Fe, and Al, entered the batch with the source of the silica. Higher quantities of Al, Ti and Fe can originate from the sand that might contain other minerals than quartz.

XRF data provided information on the presence of several transitional metals, which might be of use when the homogeneity of the set is in question. **Table 2** contains the summary of the XRF data of all six samples, where the values for each colour are presented separately as minimum, maximum and average concentrations of the oxides. Very low quantities of ZnO were detected in PG122 (green base) and PG166 (yellow decoration). The amounts of K_2O and CaO are comparable across the sample list, which suggests the same compositional glass group for all samples. It should be noted that the values of several elements in **table 1**

		K_2O	CaO	TiO_2	Fe_2O_3	CuO	SrO	Sb_2O_5	PbO
green glass	min.	1.81	4.73	0.26*	1.12	1.01	0.03	0.19*	0.23*
	max.	2.83	7.63	0.41	2.59	1.58	0.04	0.30	0.23
	average	2.34	6.11	0.32*	1.71	1.26	0.04	0.25*	0.23*
yellow glass	min.	1.83	4.50	0.32	1.35	0.50	0.03	0.91	3.38
	max.	2.05	7.20	0.34	1.79	0.58	0.03	1.41	5.12
	average	1.94	5.85	0.33	1.57	0.54	0.03	1.16	4.25
black glass	min.	2.07	4.81	0.28*	1.02	0.40*	0.03	0.19	0.10
	max.	2.86	5.88	0.30	1.63	0.43	0.03	0.93	1.59
	average	2.46	5.33	0.29*	1.24	0.42*	0.03	0.50	0.76
limit of quantification		1.20	0.15	0.07	0.04	0.40	0.01	0.07	0.03

Tab. 2 Data of XRF analyses on the samples as minimum, maximum and average values in percent for each colour of glass. The limit of quantification is the lowest quantity of oxide that could be reliably determined by the method. – *Values that do not include the values below the limit of quantification.

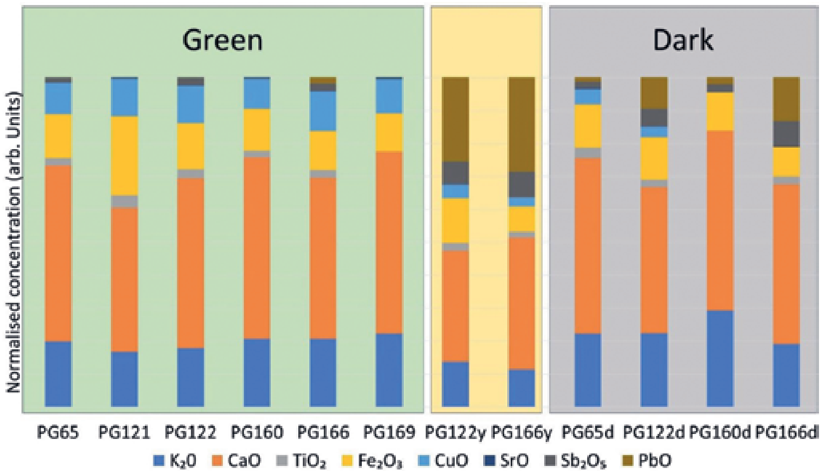

Fig. 5 Normalised concentrations of the elements detected by XRF in each sample. The data are grouped according to the colour of the glass. – (Graph O. Yatsuk).

are significantly different for the same sample from the ones determined by XRF (for example, values of Fe_2O_3 for PG121g and K_2O and CaO for PG122g). These differences can be explained by the different analytical spots (surface analysis of the area 1.3 mm across for XRF and in material from below the surface from the 80 µm spot for LA-ICP-MS), large relative errors of the measurements (especially in the XRF data for Fe_2O_3 is 33 % 2σ) and other, sample dependent sources of error (thickness, roughness, presence of bubbles, etc.). This variability has been taken into account in the discussion of the data.

Presence of Sb in low quantities in the green parts of the samples analysed by XRF can be explained by the large spot of analysis that could also include some parts of the decoration or simple dissolution of higher Sb yellow glass into the green glass. PG169 (**fig. 3**) does not have Sb or Pb, but instead, features trace quantities of tin. This might be evidence of this sample being made with slightly different raw materials, for example the Cu might have entered the batch as part of bronze scrapings (Costa et al. 2021).

It can be seen in **figure 5** that across all the types of green beads and also across all the colours of glass the amounts of K_2O and CaO are compatible. TiO_2 and Fe_2O_3 are also in similar proportions relative to the rest

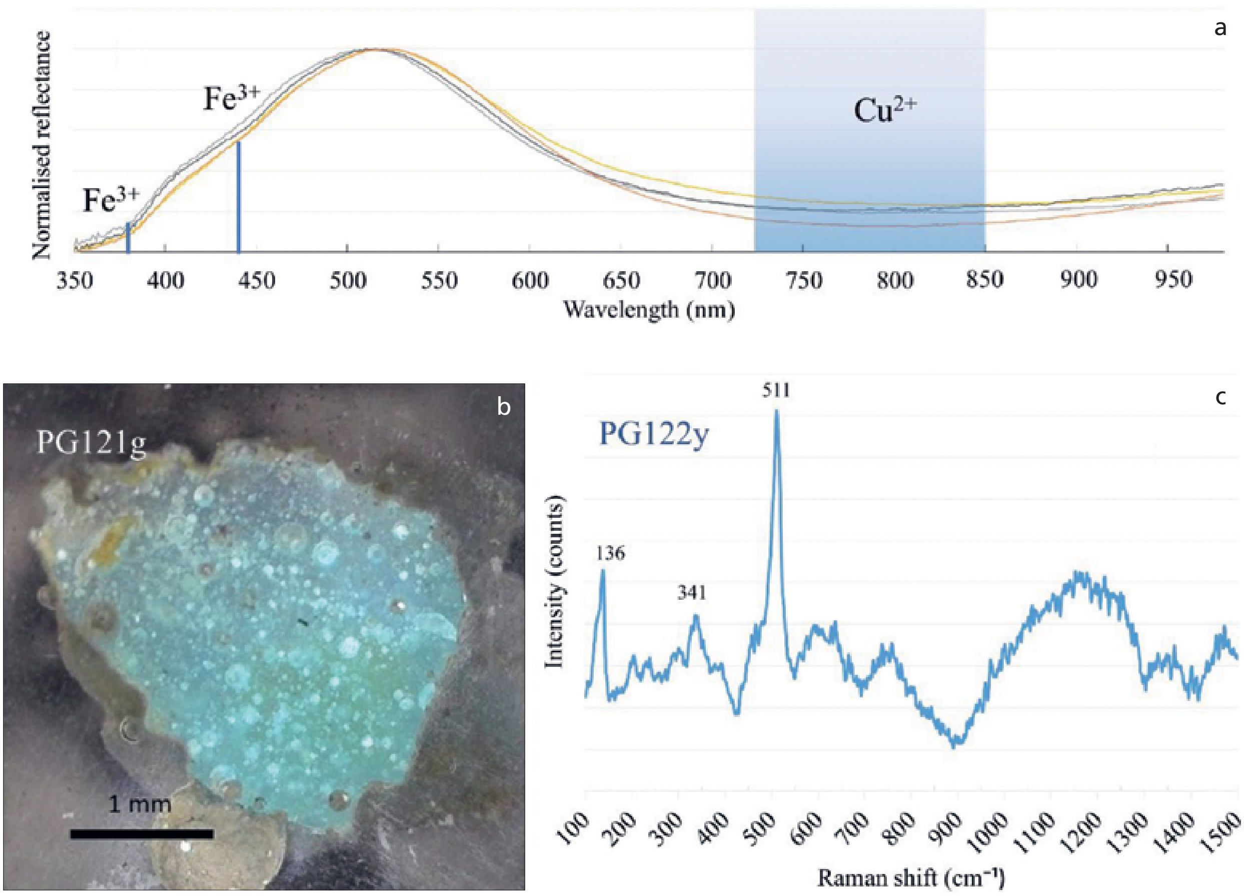

Fig. 6 Colourants/opacifiers observations. – **a** FORS spectra taken from the green glass of PG65, PG121, PG122 and PG160 showing the presence of Cu^{2+} and Fe^{3+}. – **b** microscope image of PG121 in cross-section, differently sized bubbles are visible on the surface and beneath it. – **c** Raman spectrum of the yellow part of PG122 containing peaks of lead antimonate. – (Photo and graphs O. Yatsuk).

of the elements. This similarity among the glass types suggests that all six samples are HMG as determined for PG121 and PG122 by LA-ICP-MS analysis and were made from similar glass. Certain differences occur only between differently coloured parts of the beads. The most noticeable is the presence of copper in the green matrix glass. Indeed, this also corresponds to the LA-ICP-MS data (**tab. 1**).

The FORS data confirmed that Cu^{2+} ions are present in the green glass in all samples to which the technique was applied. Cu^{2+} gives a wide absorption band centred between 720 and 850 nm, as shown in **figure 6a**. Depending on the coordination of copper ions with oxygen in the glass network, the glass can exhibit colours from blue to green and brown (Weyl 1976 [1999]). Copper was among the earliest and widespread colourants for glass in antiquity (Mass et al. 2001; Mirti et al. 2002; Arletti et al. 2006). The slight shoulders at 380 and 440 nm can be interpreted as Fe^{3+} being present. This chromophore would have contributed a yellow hue to the glass. Yet its presence probably does not influence the colour in a significant way, due to the weakness of the absorption. **Figure 6b** shows PG121 in cross-section. Fine bubbles can be observed, they contribute to the opacity of these glasses. No other opacification agents were found in the green glass and without them the glass would be translucent.

In the yellow and dark decoration glass one can observe the increase of Sb_2O_5 and PbO (**fig. 5**). These are indicators of the use of lead antimonate to give both the yellow colour and the opaque effect. This compound was widely used for this purpose from the 2nd millennium BC glass production in the Near East and

sample ID	Rb	Sr	Cs	Ba	La	Ce	Nd	Sm	Eu	Gd	Tb	Dy	Er	Yb	Lu	Hf	Tl	Th	U
PG121g	15.1	174.5	0.2	46.6	8.9	19.3	9.0	2.0	0.4	1.8	0.3	1.5	0.9	0.8	0.1	1.3	<0.01	2.9	0.5
PG122g	14.8	216.0	0.3	73.4	10.2	21.3	9.6	2.0	0.4	1.8	0.3	1.6	0.9	0.8	0.1	1.4	<0.01	3.3	0.6
PG122y	18.2	214.0	0.4	76.7	11.1	23.4	11.1	3.3	0.6	2.7	0.4	2.4	1.2	1.0	0.2	2.2	0.1	3.4	1.0
PG122d	20.7	158.7	0.3	55.2	10.0	19.9	9.6	2.4	0.5	2.4	0.3	1.9	1.1	1.0	0.1	1.6	<0.01	2.7	1.2

Tab. 3 LA-ICP-MS data on the amounts of the trace elements in the glass in parts per million. g – green, y – yellow, d – dark.

Egypt (Shortland 2002): it does not dissolve in the glass matrix and can be observed as small inclusions inside the glass. These small particles interrupt the light passing through the otherwise translucent glass and make it opaque. Raman analyses detected the presence of lead antimonate (the naturally occurring form is called bindheimite). **Figure 6c** displays the characteristic peaks of lead antimonate in the spectrum at 136, 341 and 511 cm^{-1}. Regarding the dark parts of decorations, no compositional difference in the transition metal contents were observed by XRF and LA-ICP-MS analyses. FORS was not able to detect any colouring ions, due to the high light absorption of the dark material and the difficult geometry of the measurement. Because of the content of around 1 % Fe_2O_3 and the brown colour in transmitted light (e. g. **list 2**, L3 **fig. 2c**), a colouration by strongly reduced Fe can be hypothesised.

The content of trace elements is crucial for unravelling details of the batch formula, in particular the provenance of the silica. In theory, comparison of these glass types with ones of known provenance can help to establish their origin. Measured concentrations of 19 trace elements for samples PG121 and PG122 are reported in **table 3**. It can be seen that the green glass of two samples analysed by LA-ICP-MS is not different on the level of trace elements. The larger difference between them is in the contents of Sr and Ba. This can be interpreted as a difference in the composition of the plant ash, as it is difficult to make plant ash of the same average composition. The glass of the decoration on PG122 apparently has higher levels of the rare earth elements (REE) Hf, Tl, Th and U, which can be interpreted by the use of sand with higher amount of impurities. The data of the dark decoration can be influenced by the yellow layer, owing to the nature of the measurement (the laser removes the glass gradually, going deeper and deeper into it, while the dark glass is quite thin). At the same time, the amounts of the trace elements are, as a rule, lower in the dark part.

DISCUSSION OF THE RESULTS

HMG is, probably, the oldest type of glass known to have been produced continuously from the 2nd millennium BC onwards. By the 8th century BC most of the glass produced in the Mediterranean was prepared with a mineral flux, though. This type of glass is known as »Low Magnesium Glass« or LMG and contains low amounts of magnesium and potassium (usually below 1 % weight oxide). They started to be produced in the 10th century BC and gradually replaced the HMG during the Iron Age (Shortland et al. 2006; Lončarić / Costa 2023, 3845–3846). The green glasses from Central Italy analysed here are not the only known examples of HMG in the first half of the 1st millennium BC. Coeval HMG glasses were found in Southern Italy (Conte et al. 2019) and Northern Italy (Polla et al. 2011), Rhodes (Oikonomou et al. 2012), Poland (Purowski et al. 2012; Agua et al. 2017) and Bulgaria (Tzankova / Mihaylov 2019). **Figure 7** shows that the MgO and K_2O values of the green beads (including the decorative elements) corresponds to HMG glass found in other Iron Age contexts. They are separated from the LMG and the »Low Magnesium High Potassium« (LMHK) glass

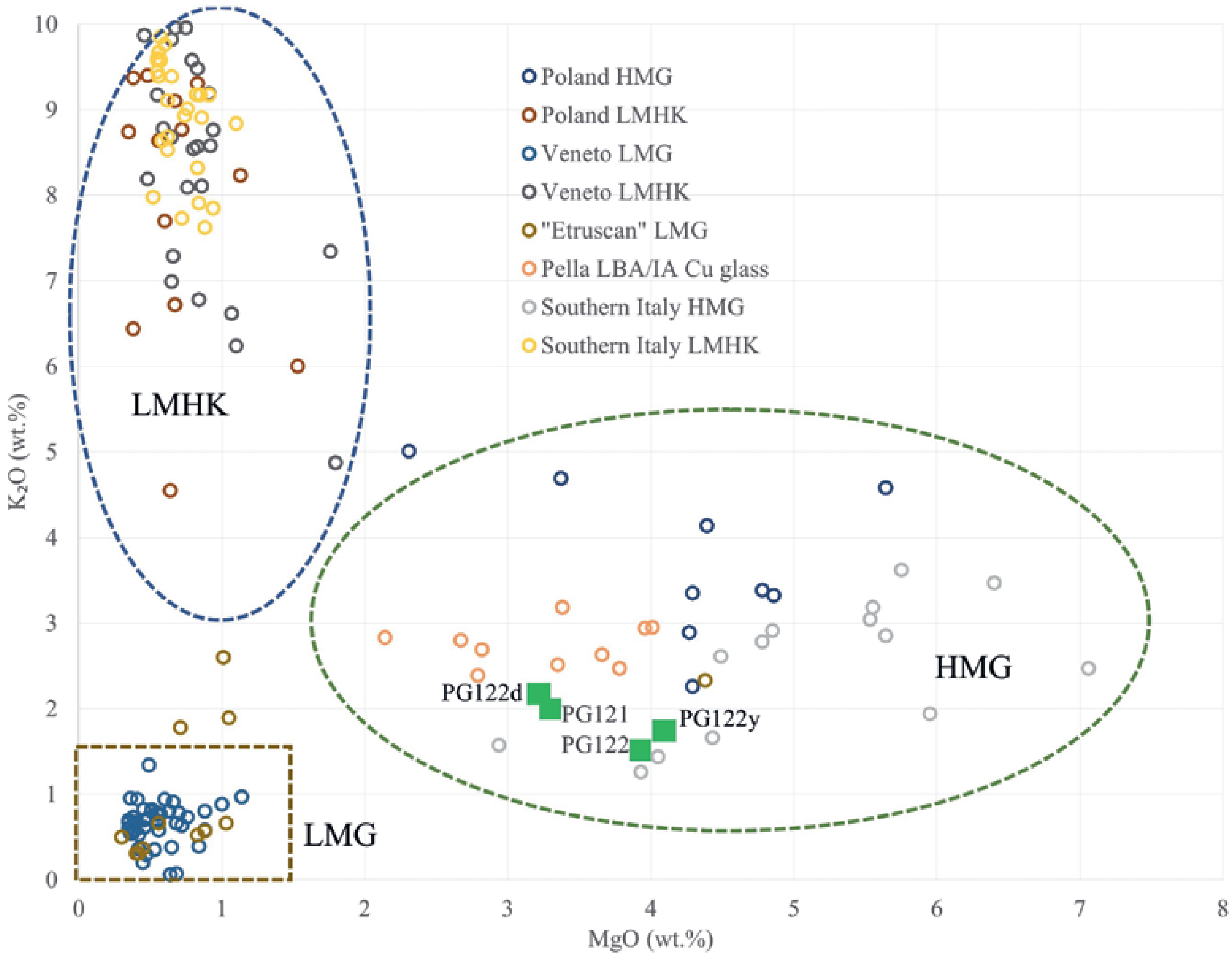

Fig. 7 MgO vs K_2O binary plot that contains the LA-ICP-MS data of PG121 and PG122 compared with other Late Bronze and Iron Age datasets. – (Graph O. Yatsuk; external sources: Poland HMG, LMHK: Purowski et al. 2018; Veneto LMG, LMHK: Towle et al. 2001; »Etruscan« LMG: Towle/Henderson 2004; Pella/JO: Reade 2021; Southern Italy HMG, LMHK: Conte et al. 2019).

used across Europe in the 12th to 9th century BC and even beyond. LMHK glass is interesting for the present discussion regarding the question of origin, because one of the suggested production sites might have been located on the Italian Peninsula – in the Po Valley in Veneto with the well-known archaeological remains of glass-working, like Frattesina di Fratta Polesine or Mariconda (Bietti Sestieri et al. 2019; Bellintani/Angelini 2020; summarised in: Koch 2021b).

Indeed, comparing trace element contents of the analysed glass with that of known provenances and finding subtle compositional parallels is decisive for suggesting provenances of glass of unknown origins. This is because most of the trace elements (including REE) are assumed to enter the batch almost exclusively with the silica source sand or quartz pebbles. Nevertheless, it has been demonstrated that grinding raw materials and heating at a high temperature in the crucible may change the trace elements' composition in the final product (Rehren 2008; Schibille et al. 2022). It is usually assumed that local sands or quartz pebbles were used as a source of silica for the raw glass production. This is not the case for fluxes, which were more difficult to obtain, especially in the case of natron, which had to be transported from the few known sources. Therefore, the trace elements' distribution in the sand usually reflects the geochemical make-up of the silica near the glass-making site. If we assume that LMHK glasses were indeed made in the Po Valley (Veneto,

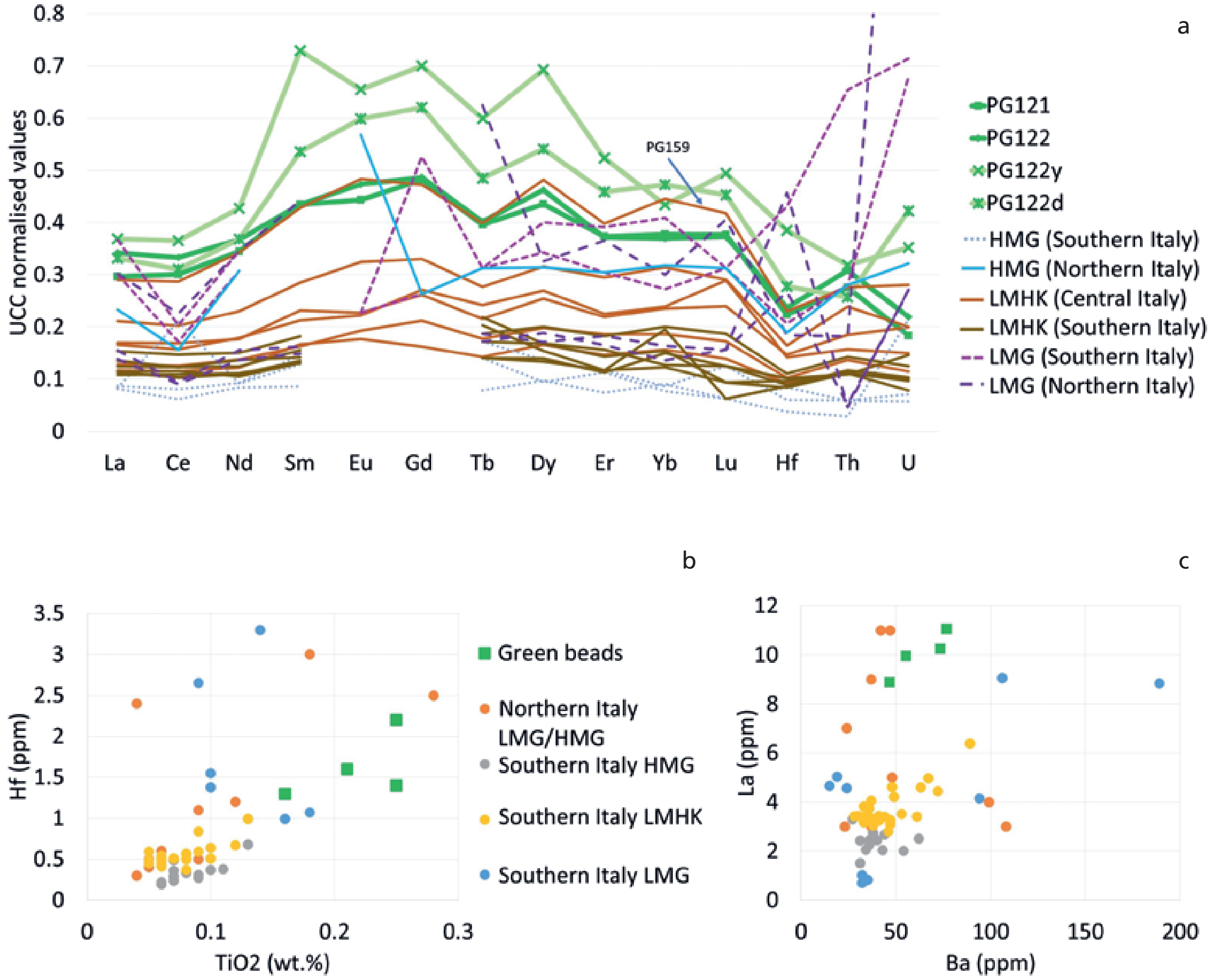

Fig. 8 Comparison of green beads with other datasets according to amounts of minor and trace elements. – **a** linear plot of REE and Hf, Th, U normalised according to the values of the Upper Continental Crust (after McLennan 2001). – **b** binary plot of TiO_2 vs Hf. – **c** binary plot of Ba vs La. The legend in plot **b** is true for plot **c**. – (Graphs O. Yatsuk; external data sources: Central Italy LMHK: Yatsuk et al. 2023; Southern Italy HMG, LMHK, LMG: Conte et al. 2019; Northern Italy HMG, LMG: Arletti et al. 2011).

Northern Italy), then they should be one of the references for tracing the provenance of the green HMG glass considered here.

Figure 8 provides a comparison of minor and trace elements' content of green beads to some coeval glasses of various compositions from several sites on the Italian Peninsula. Clearly, the glasses discussed in the present study have similar REE profiles (fig. 8a). The yellow and dark glass show higher REE concentrations than the green base glass. When compared to the LMHK glasses, it is evident that the latter do not have comparable levels of REE, but their profiles are similar with slightly higher values of mid-mass REE and relatively low Hf values. There is one sample among the LMHK glasses from Central Italy – a LMHK-ring bead from Terni-Acciaierie, where a green bead in this study was also found (list 1, A4) – which has comparable values of trace elements (PG159). This similarity in the general REE profile suggests a similar geological origin of the silica source. Given the high alumina and titania contents in the green beads, one might assume the use of sand instead of quartz pebbles. This sand was rich in light and heavy minerals that contributed

relatively high amounts of the REE and other trace elements. However, the sand seems to be relatively poor in zircon, the major bearing mineral of Hf.
Other HMG objects considered in figure 8a contain even lower amounts of trace elements than the LMHK glasses, except one sample from Bologna (Arletti et al. 2011, tab. 2 sample FiBo21), which has a different REE profile though. Among the LMG of the period, those with high relative concentrations of REE are rather exceptional. In figure 8 we included these high REE LMG glass pieces, to check if there is a similarity with HMG glass in the present study. It emerged that these LMG glasses from Southern and Northern Italy do not follow the same pattern. They usually demonstrate a relatively low Ce content, others a relatively high Hf content. In general, the similarity with LMG glasses is even lower than with HMG ones.
As a whole, we can say that the profile of LMHK glass trace elements is the closest with the set of beads discussed here. It can be seen that the TiO_2 and even Hf content of the green beads is systematically higher than the majority of the coeval beads found on the Italian Peninsula (fig. 8b). These beads also have increased La values, which places them in a unique area on the Ba/La binary plot (fig. 8c). Some samples from Bologna have comparable values of these elements, though they are not similar compositionally (some of the Bologna samples' composition is influenced by the cobalt colourant and are rather LMG than HMG). Green glasses from the present study do not overlap with LMHK glasses from Southern Italy in figure 8b–c. This is because of their general enrichment in the silica related elements, probably caused by the use of sands richer in heavy mineral impurities than typical LMHK glass representatives. For this reason, in the attribution we relied on the similarity of their REE profiles.

CONCLUSIONS

Given the general profile similarity for REE with the earlier LMHK glasses, we propose a local, Italian origin for both the matrix glass and the decorative glass of the green beads. The HMG of the finds in the present study was obtained from chemically impure silica (sand with high amounts of minerals other than quartz). Certain technical aspects of the glass composition support a local origin: First, it would be simpler to produce HMG on the Italian Peninsula than the LMG more popular at the time, because halophytic plants were available, whereas the evaporitic deposits of natron were not. Such a preference for the plant-based flux for the small-scale glass production away from the major glassmaking centres of the time is not unique: HMG was produced in the 6th century BC in the Yahorlyk workshop on the Black Sea shore (Kolesnychenko/Yatsuk 2021). Second, the appearance of the green glass and the means of achieving it are unique. During the Late Bronze Age in Egypt until Roman times, opaque green glass was obtained by mixing the colourant (a Cu compound) with antimony compounds as a opacifier (Mass et al. 2001; Lankton et al. 2022; Bettineschi et al. 2020, specimen NR-PR-V 14A; Angelini et al. 2019, 190 tab. 3; Franjić et al. 2022, 26). In the present study, antimony is only present in meaningful quantities in the yellow decorative glass. Bubbles can be the sign of the ingenuity of local glass-makers (in the case of an intentional introduction) or appear due to the lack of experience (unintentional introduction). In any case, the artisans knew the technology of glass opacification, as is evident from the yellow glass of the same origin. This decorative glass can be considered to be one of the first examples of opaque yellow glasses of the Iron Age on the Italian Peninsula among ones in Picenum (de Ferri et al. 2020; Catalogue Ancona 1998, 45–46) and Southern Italian ones from Francavilla, which may have been imported (Conte et al. 2019; Quondam in print).
Based on the above-mentioned facts and the distribution of HMG green beads, a small-scale glass production in Central Italy can be reasonably suggested. The craftspeople were using local raw materials and created objects of a unique chemical composition. This conclusion should remain tentative, until more

data are gathered both from the archaeological and analytical chemistry fields. Despite the existence of an independent LMHK glass industry in the Final Bronze Age, the new Iron Age production in the region relied on the different HMG tradition. Yet, this assemblage, unless more objects of similar composition are found, represents only a small-scale production, perhaps merely several batches, which could be experimental. The additionally analysed glass bead PG169 of similar composition and peculiar appearance (**fig. 3**) with supposed imperfections is a further indication of this. If this point were to prove true, it would be a remarkable fact, because most of the glass that circulated in the early centuries of the 1st millennium BC seems to have been imported from the Eastern Mediterranean (Towle / Henderson 2004; Arletti et al. 2011; Conte et al. 2019; de Ferri et al. 2020; Lončarić / Costa 2023) or is of Final Bronze Age inheritance (Yatsuk et al. 2023).

LIST 1: GREEN BEADS WITH TWO OR THREE DARK-YELLOW SPIRAL EYES

A1. Osteria dell'Osa fig. 1a (PG122)
(Rome, Latium) grave 10 (Phase IIIA)
Bietti Sestieri 1992a, 756 fig. 3a.405 no. 59 – type 89j
Museo delle Civiltà – »Luigi Pigorini« inv. no. 109409
Flattened spherical to ring-shaped bead with three spiral eyes, two of which are strongly plastically protruding, one broken off, otherwise complete. One spiral eye is fused obliquely. Inside, originally a piece of the bronze wire on which the beads were threaded. Matrix glass on the surface with many bubble holes, slight winding streaks, some cracks, otherwise homogeneous glass that appears opaque due to bubbles. Yellow decorative glass bubbly and porous; dark glass also with some bubbles, but shiny.
Dm.: 1.0 cm
H.: 0.72–0.8 cm
Width opening: 0.35/0.35–0.32/0.32 cm
Wt.: 1.1 g

A2. Osteria dell'Osa fig. 1b
(Rome, Latium) grave 99 (Phase IIIB)
Bietti Sestieri 1992a, 821 no. 14a (with further beads and bronze wire of the brooch pendant)
Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma (SSABAP-RM) inv. no. 379831
Flattened spherical bead completely preserved in form, but one eye has fallen out except for remnants of dark decorative glass, and the entire surface appears eroded, partially devetrified with loss of colour of the green matrix glass, which is heavily interspersed with cracks and with many bubble holes (secondary heat? The loss of weight could also speak in favour of this). While the yellow decorative glass is bubbly and crumbly, with lighter and darker inclusions, the dark decorative glass is covered with a white patina that has not been observed on any other bead. Dark overlay in the opening. This bead appears to have been exposed to particularly adverse storage conditions – compare the condition of the bead with yellow-dark line decoration from the same grave **list 2**, L2 **fig. 2b** – and may have come to the bead collection of grave 99 as a collected old piece.
Dm.: 0.93–1.02 cm
H.: 0.59–0.60 cm
Width opening: 0.31/0.32–0.32/0.32 cm
Wt.: 0.4 g

A3. Sermoneta-Caracupa fig. 1c (PG166)
(prov. Latina, Latium) grave 91 (Lazio III)
Bartoloni in: Catalogue Rome 1976, 361–362 no. 12 tab. XCVIII. The only bead in a woman's grave with a large bronze knife and a bronze tripod bowl.
Museo delle Civiltà – »Luigi Pigorini« inv. no. 73131
Glued together from two fragments, complete except for a small amount of missing yellow decorative glass. The bead body is unevenly coiled, the opening eccentric. Matrix glass heavily interspersed with bubbles, which are also visible under the surface, glass nevertheless compact and slightly translucent in appearance. Decorative glass as in **list 1**, A1, but yellow glass with light (quartz grains?) and dark (sediment? yellow antimony pigment?) inclusions.
Dm.: 1.10–1.12 cm
H.: 0.50–0.68 cm
Width opening: approx. 0.4 cm (cannot be measured exactly, as the pin for attachment sticks to the bead)
Wt.: 1 g (with pin)

A4. Terni, S. Agnese, Acciaierie fig. 1d (PG160)
(prov. Terni, Umbria) without grave conext
unpublished
Museo delle Civiltà – »Luigi Pigorini« inv. no. 67722
Green bead, flattened spherical, with only two eyes, of which only remnants of dark glass survive, very small remnants of yellow glass, apparently from a spiral. Matrix glass heavily bubbled, distinct streaks on the surface, partly eroded; dark streaks from an eye to the other (decorative glass?).
Dm.: max. 1.02 cm

H.: 0.89–0.92 cm
Width opening: 0.23/0.25–0.27/0.27 cm
Wt.: 1.0 g

A5. Crustumerium
(Rome, Latium) in connection with grave 390 (project »The People and the State« Institute of Archaeology University Groningen and the Soprintendenza Speciale per i Beni Archeologici di Roma)
unpublished
Flattened spherical bead with three spiral eyes, completely preserved except for minor losses of the yellow decorative glass. The eyes slightly protruding from the matrix, with few windings.

A6. Kamiros / London
(Rhodes / GR)
https://www.britishmuseum.org/collection/search?keyword=1977,0624.6 (14.2.2024)
Shape somewhat crooked ring-shaped to pressed spherical, only two eyes are visible in the photo, one eye seems to have fallen out completely, leaving a dent, the other well preserved, including the yellow decorative glass, and fused flat. The body of the bead is turquoise in the photo, so the colour shade is more blue than the green beads presented, but this may be a problem with the exposure or calibration of the screens; the matrix glass also appears to be very bubbly, with horizontal streaks on the surface.

LIST 2: GREEN BEADS WITH A LINE DECORATION OF A DARK-YELLOW RETICELLA STRIPE

L1. Osteria dell'Osa fig. 2a (PG121)
(Rome, Latium) grave 10 (Phase IIIA)
Bietti Sestieri 1992a, 756 no. 63
Museo delle Civiltà – »Luigi Pigorini« inv. no. 109407
Four fragments representing about a quarter of the whole bead, the H of the bead can be measured completely. The matrix glass shows many bubble holes on the surface, in the fracture and in the groove, but is translucent in transmitted light. In the largest fragment, a groove can be seen running around the belly of the bead, which is the result of the lost decoration stripe.
Largest fragment: H.: 0.62 cm; B.: 0.55 cm; width of groove: c. 0.35 cm

L2. Osteria dell'Osa fig. 2b
(Rome, Latium) grave 99 (Phase IIIB)
Bietti Sestieri 1992a, 821 fig. 3c.6 no. 14a (with further beads and bronze wire of the fibula pendant), type 89m var. IV
Soprintendenza Speciale Archeologia Belle Arti e Paesaggio di Roma (SSABAP-RM) inv. no. 379831
Pressed-spherical bead, almost completely preserved, the opening is slightly off-centre. Matrix glass slightly translucent, interspersed with bubbles, some cracks on the surface, there lighter and more yellowish. The yellow-dark decorative band is not completely laid around the body, as can also be observed in less well-preserved pieces (see **list 2**, L4 and L5 Sermoneta-Caracupa 60 and Vetulonia **fig. 2d–e**). The reticella thread is very regularly fused together, but the yellow decorative glass is less well preserved than the dark one (cf. **list 2**, L3).
Dm.: 0.86–0.88 cm
H.: 0.59–0.69 cm
Width opening: 0.24/0.26–0.26/0.27 cm
Wt.: 0.7 g

L3. Sermoneta-Caracupa fig. 2c (PG165)
(prov. Latina, Latium) grave 8
unpublished
Museo delle Civiltà – »Luigi Pigorini« inv. no. 69688
Irregularly ring-shaped to pressed-spherical; glued together from several fragments, breaks run horizontally and vertically, approx. a quarter of the bead body is missing, the yellow decorative glass has fallen out except for a few remnants. Dark decorative glass appears brown in transmitted light. The decoration runs around three quarters of the bead body. Matrix glass heavily interspersed with bubbles, especially in the break.
Dm.: 0.8 cm
H.: max. 0.47 cm
Width opening: 0.30–0.31 cm
Wt.: 0.3 g left

L4. Sermoneta-Caracupa fig. 2d
(prov. Latina, Latium) grave 60
unpublished
Museo delle Civiltà – »Luigi Pigorini« inv. no. 89872
Spherical to pear-shaped bead, complete except for decorative thread, from this small remnants of dark and yellow glass (next to white-crystalline inclusions, unknown material), one crack and accumulation of bubbles in the remaining groove. The matrix glass is strongly bubbled, opaque in appearance, with faint horizontal winding streaks on the surface.
Dm.: 0.65–0.7 cm
H.: 0.60–0.61
Width opening: 0.22/0.25–0.22/0.24 cm
Wt.: 0.4 g left

L5. Vetulonia, Poggio alla Guardia fig. 2e
(prov. Grosseto, Toscana) grave VII del I Circolo interrotto (Scavo I. Falchi 1886)
Maggiani 1973, 88: 750–720 BC; the grave contains 30 other glass beads, including a black one with red and white spots (Koch 2021, fig. 7.5) spindle-shaped and long cylindrical ones with spiral decoration (Maggiani 1973, 77–79 fig. 3; cf. also Colombi 2018, type B19.2c, colour pl. 17.6–7).
Museo Archeologico Firenze inv. no. 6104F
Pressed-spherical bead, complete except for the decorative thread, which ran around approx. three quarters of the bead; shape somewhat crooked due to the sinking in of the decorative glass. Matrix glass with many bubble inclusions, some soil still present, light-coloured deposits inside the opening. Some cracks along the groove, where the glass appears more yellowish.
Dm.: 0.9 cm
H.: 0.66 cm
Width opening: 0.22–0.27 cm

L6. Narce, V sepolcreto del Pizzo
Piede (Civita Castellana, prov. Viterbo, Latium) grave 22 (LVII)
B. Giuliani in Catalogue Villa Giulia 2012, 76–77 no. II.24; ca 675 B. C. Grave richly furnished with pottery, containing figurative amber pendants, scarabs and seven Egyptianised faience figurines as pendants.
Ring-shaped bead, apparently completely preserved, including the reticella thread in yellow and dark. It is not possible to judge whether the decorative thread surrounded the entire bead. The matrix glass appears turquoise in the photo (cf. list 1, A6).
Dm.: max. 1 cm

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Notes

1) For Frattesina see recently: Angelini 2019; Bietti Sestieri et al. 2019; Bellintani / Angelini 2020; outline in: Koch 2021b.
2) Recent summary: Lončarić / Costa 2023, esp. 3842–3844. 3848; previously: Polla et al. 2011; Koch 2021a, 10–13.
3) Pressing the decoration glass into the surface, as is still often believed and published, is not necessary. The misconception probably goes back to Beck's regular description of »impressed« decoration.
4) www.perlenschmiede.eu (13.3.2024). I would like to thank Ch. Rupp cordially for explaining different procedures, providing photos and for making the beads.
5) The manufacturing was done with modern glass, which certainly differs in melting behaviour and workability from the Iron Age HM-glass; nevertheless, general processes can be reconstructed and traced. A spiralled cone was also created in the process described by Rolland (2021, 146–150 fig. 86), but worked directly on the bead.
6) I would like to thank M. Grunert, who dealt with the production techniques of glass beads in her MA thesis »Die Verwendung von Glas im 1. Jahrtausend v. Chr. im Norddeutschen Tiefland« (Universität Hamburg), very much for her willingness to discuss matters and for providing the photos.
7) Thanks to a research stay at the DAI Rome in 2016, I was able to examine almost all prehistoric glass beads at the Museo delle Civiltà. My special thanks go to the staff of the museum.
8) For this opportunity I would like to thank very much A. De Santis, Rome.
9) Kind oral communication by A. De Santis; I have to thank B. Belelli Marchesini and A. Nijboer for information on the bead from Crustumerium (most recently: Attema / Bronkhorst 2020).
10) Online collection of the British Museum: https://www.britishmuseum.org/collection/object/G_1864-1007-2000 (13.3.2024). The matrix glass is described as white, but it seems rather to be a translucent brown or »amber« glass with a patina.

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Zusammenfassung / Summary / Résumé

Grüne Perlen mit Reticella-Dekoration aus dem 8. Jahrhundert v. Chr. in Italien – Zur Art und chemischen Zusammensetzung einer ungewöhnlichen Form

Glasperlen der frühesten Eisenzeit in Italien sind immer noch wenig systematisch untersucht. Hier werden zwei Formen vorgestellt, die aufgrund des gemeinsamen grünen, durch Kupfer gefärbten Matrixglases, kombiniert mit einer gelb-dunklen Verzierung, ungewöhnlich für die erste Hälfte des 1. Jahrtausends v. Chr. sind. Sie datieren in das 8. Jahrhundert v. Chr. und sind vor allem aus dem *Latium Vetus* überliefert, bleiben aber selten. Mit einer Parallele auf Rhodos scheinen sie aus der Ägäis importiert zu sein, doch ist aufgrund ihrer Ähnlichkeit in der Spurenelement-Signatur mit den typisch italischen endbronzezeitlichen Perlen der LMHK-Glas-Gruppe nun auch eine Rohglasproduktion und Herstellung dieser Perlen in Italien denkbar.

Green Beads with Reticella Decoration of the 8th Century BC in Italy – On the Type and Chemical Composition of an Unusual Form

Glass beads of the earliest Iron Age in Italy have still not been systematically analysed. Here, two forms are presented, which, according to their common, green glass matrix obtained from copper, combined with a yellow-dark decoration, are unusual for the first half of the 1st millennium BC. They date to the 8th century BC and occur especially in *Latium Vetus*, but remain seldom. With a parallel on Rhodes, they seem to have been imported from the Aegean, yet, according to their similarity in the combination of trace elements with typical Italian Final Bronze Age beads of the LMHK glass group, a raw glass production and bead manufacture in Italy seem now to be imaginable.

Translation: C. Bridger

Perles vertes à reticella du 8e siècle av. J.-C. en Italie – Sur le type et la composition chimique d'une forme inhabituelle

On ne dispose jusqu'ici que de peu d'études systématiques sur les perles en verre du début de l'âge du Fer en Italie. Sont présentées ici deux formes qui sont exceptionnelles pour la première moitié du 1er millénaire av. J.-C. par leur matrice de couleur verte due au cuivre et leur décor jaune foncé. Elles datent du 8e siècle av. J.-C. et nous parviennent surtout du *Latium Vetus*, mais elles restent rares. Une pièce similaire à Rhodos plaiderait pour une origine égéenne, mais leur signature en éléments traces les rapproche des perles du groupe de verre LMHK typiques pour le Bronze final en Italie et permet d'envisager une production de verre brut et la fabrication de ces perles en Italie.

Traduction: Y. Gautier

Perle verdi con decorazione a reticella dell'VIII secolo a. C. in Italia – Sulla tipologia e sulla composizione chimica di una forma insolita

Le perle di vetro (»pasta vitrea«) della Prima Età del Ferro in Italia sono ancora poco studiate in modo sistematico. Vengono qui presentati due tipi insoliti per la prima metà del I millennio a. C., poiché caratterizzati da un corpo in vetro verde colorato con rame, combinato con una decorazione giallo-scura. Queste perle datate all'VIII secolo a. C. sono state trovate soprattutto nel *Latium Vetus*, anche se restano rare. A causa di un ritrovamento parallelo a Rodi, ne era stata ipotizzata un'importazione dall'Egeo. Le analisi chimiche hanno tuttavia evidenziato un andamento della concentrazione degli elementi in traccia sovrapponibile a quello delle tipiche perle italiche dell'Età del Bronzo Finale del gruppo di vetri LMHK, pertanto è ora ipotizzabile una produzione primaria del vetro grezzo e la fabbricazione di queste perle in Italia stessa.

Schlüsselwörter / Keywords / Mots-clés

Latium / Etrurien / Frühe Eisenzeit / vorgeschichtliche Glasperlen / chemische Zusammensetzung von Glas
Latium / Etruria / Early Iron Age / Prehistoric glass beads / glass chemical composition
Latium / Étrurie / premier âge du Fer / perles de verre préhistoriques / composition chimique du verre
Latium / Etruria / prima Età del Ferro / perle di vetro protostoriche / composizione chimica di vetro

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