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Emeralds, sapphires, pearls and other gemmological materials from the Preslav gold treasure (X century) in Bulgaria

Elisabeth Strack, Ruslan I. Kostov

Abstract. The Preslav gold treasure (adornments from gold decorated with enamel, beads of gem minerals and pearls: diadem, bilateral necklace, medallions, several earrings and earcaps, rings, buttons, appliqués and other small finds) was found in 1978 near the town of Veliki Preslav – the second Bulgarian capital during the end of the First Bulgarian Kingdom. The treasure (X century) belonged to a female member of the royal family and is suggested to be of a Byzantine origin. A morphometric study and gem testing was made on all the gemmological materials – minerals and numerous pearls. Among the gem minerals are identified 40 emeralds, 12 violet sapphires, 10 reddish violet garnets, 5 rock crystals, 3 amethysts and 1 carnelian. Their inclusions and type of cut are listed. The average dimensions for the emerald polished and rounded on the edges prisms from two medallions are: length 0.48 cm and width 0.59 cm. The average dimensions for the mainly barrel shaped sea pearls from a gold medallion are length 0.40 cm and diameter 0.45 cm. The origin of the emeralds is under discussion, and they are compared with other emerald finds in Europe, including from Bulgaria, from the Antiquity and Early Medieval Period. As a probable source for the gem minerals (emerald, sapphire, garnet), according to their inclusions, is suggested an Eastern (India and Sri Lanka) origin (alternative for the emeralds – the Hindou-Kush area), and the pearls are probably from the Indian Ocean of the Persian Gulf.

Key words: emerald, sapphire, garnet, quartz, pearl, Preslav, gold treasure

Addresses: E. Strack – Gemmologisches Institut Hamburg, Gerhofstraße 19, 20354 Hamburg, Germany; E-mail: info@strack-gih.de; R.I. Kostov – University of Mining and Geology "St. Ivan Rilski", 1700 Sofia, Bulgaria

Елизабет Щрак, Руслан И. Костов. Смарагди, сапфири, перли и други гемологични материали от Преславското златно съкровище (X век) в България

Резюме. Преславското златно съкровище (златни украшения декорирани с емайл, мъниста от скъпоценни минерали и перли: диадема, двустранна огърлица, няколоко обеци и наушници, пръстени, копчета, декорации и други малки находки) е намерено през 1978 г. близо до град Велики Преслав – втората българска столица в края на Първото българско царство. Съкровището (X век) е с византийски произход и е принадлежало на лице от женски пол – представител на царската фамилия. Извършено е морфометрично изучаване и гемологична диагностика на ювелирните материали – минерали и множество перли. Сред скъпоценните минерали са идентифицирани 40 смарагда, 12 виолетови сапфири, 10 червеникаво виолетови гранати, 5 планински кристала, 3 аметиста и 1 карнеол. Отбелязани са техните включения и вида на обработка. Средните размери на заоблени и полирани смарагдови призми от два медальона са: дължина 0,48 cm и ширина 0,59 cm. Средните размери на предимно бъчвовидни морски перли от златен медаьон са дължина 0,40 cm и диаметър 0,45 cm.

Произходът на смарагдите е дискусионен, като те са сравнени с други находки на смарагд в Европа, включително от България, от античната и ранната средновековна епоха. Като вероятен за скъпоценните минерали (смарагд, сапфир и гранат), въз основа на техните включения се приема източен (Индия, Шри Ланка) произход (алтернатива за смарагда – районът на Хиндукуш), а перлите са вероятно от Индийския океан или Персийския залив.

Introduction

The medieval settlement of Preslav (now Veliki Preslav) was founded during the VIII to IX century. It has been proclaimed the second capital of Bulgaria in 893 and is related to the reign of Tsar Simeon the Great. It was captured in 969 by prince Sviatoslav of Kiev and in 971 by Byzantine emperor John I Tzimisces, and later on the Bulgarians reoccupied it in ca. 986, and the Byzantines – about the year 1000 The traditional occupations of the area of the royal palace were agriculture, livestock breeding, viticulture and materials have been found that testify to almost all kinds of manufacturing: ironwork, pottery, ceramics for everyday use, luxury ceramics, painted ceramics, glasswork, jewellery, ivory, and marble (Jordanov, 2002).

The so called Preslav Treasure (adornments from gold decorated with enamel, gem minerals and pearls: diadem, bilateral necklace, medallions, several earrings and earcaps, rings, buttons, appliqués and other small finds), which was found in 1978 about 3-4 km NW from the palace complex of Preslav, obviously belonged to a member of the royal Bulgarian family (a Byzantine gift to a daughter of tsar Peter I or tsar Boris II) and has direct analogues to the ornaments of the noblest and high ranking Byzantine women (*Archaeological Museum*…; Totev, 1986; 1993; Atanasov, 1999a; 1999b). It is well known from historical sources, that according to the firmly established tradition the basileus make gift crowns (diadems) only to royal persons (Twining, 1967, 27-32). The royal insignia and jewellery of the Bulgarian kings and members of their family are compared to other finds and images from the Byzantine period (Atanasov, 1999a). The interpretation of the main jewellery objects is illustrated on Fig. 1.

As the gem minerals and pearls have not been described by specialists in gemmology, a more detailed preliminary study has been made on the objects with gemmological materials, with special interest on emeralds in respect to their origin. The Preslav gold treasure is of special importance as among its objects is a representative of the only Medieval "crown" and other female royal insignia found in Bulgaria (X century – during the end of the First Bulgarian Kingdom), as well as it is one of the few representatives in Europe from the Byzantine jewellery workshops. The gold cloisonné enamel platelets of the diadem, necklace and other jewellery objects are not discussed. The inventory numbers and weight of the artefacts are given according to the

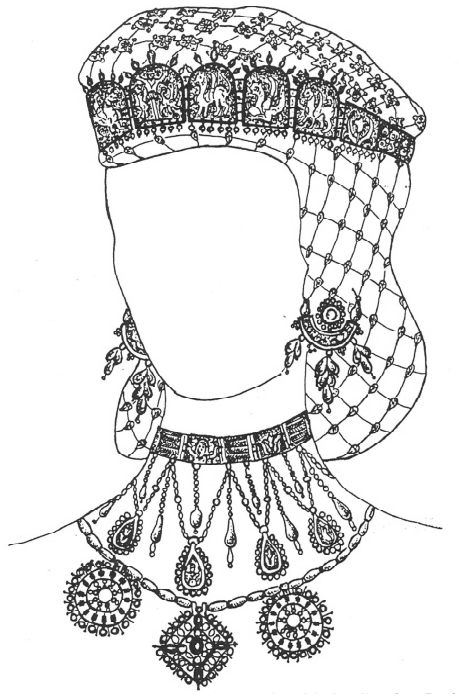

Fig. 1. Reconstruction of the gold diadem, necklace, earcaps and medallions, decorated with gem minerals, pearls and cloisonné enamel from the Preslav treasure (X century) (after Atanasov, 1999a; 1999b)

published catalogue (*The Preslav Treasure*, 2007). Several optical instruments have been applied for the study: stereoscopic microscope (MBS-9), refractometer, polariscope and UV lamp (Eickhorst System with both SW 254 nm and LW 366 nm light). Morphometric measurements are done both under the microscope and by a Leveridge gauge.

Gemmological study

Emeralds and pearls from a pear of gold medallions, probably part of a necklace

The gold medallions are round in shape and made of massive gold (Inv. N3381.3a and N3381.3b; weight 33.4 g and 31.6 g). The two concentric rings are linked with gold wire. They have been decorated with pearls in the outer (23 in number – not preserved) and inner (10 in number – preserved only in the second medallion) belt, and the middle belt – with emeralds (15 in numbers). The center circle in both cases has been probably decorated with enamel, which is missing.

Dimensions of medallion N1: central gold circle, inner diameter 0.9 cm, outer diameter 1.2 cm; first gold ring, diameter 2.5-2.6 cm; second gold ring, diameter 4.2-4.4 cm; outer diameter, 5.0 cm; thickness 0.49-0.50 cm; hook base, 0.75 cm; round hook, width 0.55 cm, diameter 0.8 cm; both hooks, height 0.75 cm, gold "nails" in the first belt, 0.55-0.6 cm, diameter of head of "nail" 0.2-0.25 cm; width of circle hooks on the outer third belt, 0.4-0.5 cm (Figs. 2-3). The measurements and characteristics of the emerald beads are listed in Table 1.

Dimensions of medallion N2: central gold circle, inner diameter 0.9 cm, outer diameter 1.2 cm; first gold ring, diameter 2.55-2.6 cm; second gold ring, diameter 4.0-4.1 cm; outer diameter, 5.0 cm; thickness 0.50 cm; hook base, 0.9 cm; round hook, width 0.7 cm, diameter 0.9 cm; both hooks, height 1.0 cm, gold "nails" in the first belt, 0.55-0.6 cm, diameter of head of "nail" 0.2-0.25 cm; width of circle hooks on the outer third belt, 0.4-0.5 cm, diameter 0.33-0.39 cm (Figs. 4-5). The measurements and characteristics of the emerald

Table 1. *Dimensions of emeralds (numbers start under the hook clockwise from 1 to 15) from medallion N1*

N	Length, cm	Diameter, cm	Notes
1	0.47	0.55	hexagonal prismatic shape with 6 faces, face width 0.24 cm; rounded edges; bases – one flat and one with rounded edges; several cracks; distinct inclusions
2	0.44	0.57	hexagonal prismatic faces; slightly better polished; broken edge; very distinct inclusions
3	0.55	0.54	polished, rounded so that the crystal faces are not visible
4	0.22; 0.22	0.66; 0.50	two hexagonal slabs; broken on the bases; distinct inclusions
5	0.57	0.57	hexagonal shape; of a low polish; smooth edges; small prismatic transparent inclusions parallel to the c-axis; also long prismatic inclusions of amphibole and white mica inclusion with pseudohexagonal shape
6	0.44	0.67	polished; white mica inclusion with pseudohexagonal shape
7	0.48	0.45	polished, rounded so that crystal faces are not visible
8	0.50	0.55	hexagonal prismatic shape; polished edges; distinct inclusions
9	0.42-0.38	0.58	polished; irregular mica inclusions and an inclusion of a dark coloured unidentified mineral phase
10	0.45	0.64	good polish
11	0.50	0.48-0.50	hexagonal prismatic shape; polished edges
12	0.50	0.54	hexagonal prismatic shape; polished edges; broken; mica inclusion
13	0.48	0.64	polished, rounded so that no crystal faces are seen
14	0.42	0.64	hexagonal prismatic shape; polished edges; transparent inclusions
15	0.48	0.54	polished, rounded and no crystal faces are visible
	0.47	0.57	average value

Fig. 2. Emeralds from gold medallion N1

Fig. 3. Emeralds from gold medallion N1, detail

Fig. 4. Emeralds and pearls from gold medallion N2

Fig. 5. Emeralds and pears from gold medallion N2, detail

Fig. 6. Shape and quality of pearls in the medallion N2

beads are listed in Table 2. The measurements and characteristics of the pearls are listed in Table 3 (Fig. 6).

The average dimensions for the emerald polished and rounded on the edges prisms from both medallions are: length 0.48 cm and diameter 0.59 cm. Most of them have cracks perpendicular to the prismatic hexagonal zone and internal striation. Because of the internal defect most of them are non-transparent or translucent. The colour of the emeralds is pale green, green to dark green. In medallion N1 as best in colour and transparency are emeralds 1, 3, 5, 9, 10 and 14. In medallion N2 as best in colour and transparency are emeralds 1, 6, 7, 8, 10, 11 and 15. All of the broken pieces are of inferior pale green colour and transparency. The emeralds have no luminescence with one exception (emerald 10 from medallion N1 with a weak yellow fluorescence in the LW light). The inclusions are represented by transparent prismatic negative crystals (gas-liquid inclusions) perpendicular to the c-axis, pseudo-hexagonal mica and long prismatic amphibole (probably tremolite). All are polished to a different degree (probably some sort of tumbling) along the edges of the natural crystals.

The average dimensions for the pearls are: length 0.40 cm and diameter 0.45 cm. Most of them have a barrel shape. They are supposed to be sea water pearls. The number [10 pearls + 15 emeralds + 23 pearls; for example – (10x23):15=15.333…; or (10+23):15=2.2; or $(10^2+15^2+23^2):23^2=1.614…$is the golden mean 1.618] and colour (white-green-white) symbolism of the gems in the belts of the medallions is not interpreted.

Table 2. *Dimensions of emeralds (numbers start under the hook clockwise from 1 to 15) from medallion N2 (+ length of broken bead)*

N	Length, cm	Diameter, cm	Notes
1	0.55	0.68	hexagonal prismatic shape; polished with smooth faces; distinct inclusions
2	0.58	0.68	hexagonal prismatic shape; slightly better polished
3	0.20+	~0.50	polished; broken half piece; mica inclusion
4	0.35+	0.72	polished; broken half piece
5	0.55	0.65	polished, rounded so that crystal faces are not seen
6	0.50	~0.40	polished, rounded so that crystal faces are not seen
7	0.40	0.72	polished, rounded so that crystal faces are not seen
8	0.50	0.48	polished, rounded so that crystal faces are not seen
9	0.55	0.48	polished, rounded so that crystal faces are not seen; broken half piece along the prismatic zone
10	0.48	0.62	good polish; broken on edge
11	0.58	0.50	polished edges
12	0.40	0.70	polished edges
13	0.54	0.68	polished edges
14	0.57	0.50	smoothed all over
15	0.60	0.69	polished edges
	0.49	0.60	average value

Table 3. *Dimensions of pearls (numbers start under the hook clockwise from 1 to 10) from medallion N2*

N	Length, cm	Diameter, cm	Notes
1	0.40	0.45	barrel shape
2	0.45	0.48	barrel shape
3	0.35	0.45	button shape
4	0.43	0.45	barrel shape with concentric circles
5	0.38	0.45	button shape
6	0.40	0.40	barrel shape
7	0.40	0.45	barrel shape
8	0.35	0.43	high button shape
9	0.40	0.45	barrel shape
10	0.40	0.45	barrel, but slightly baroque shape
	0.40	0.45	average value

Violet sapphires and pearls in a gold medallion

The gold medallion is of a rhombic shape (Inv. N3381.4, weight 28.9 g), probably worn as central part between the two mentioned medallions with emeralds and pears on a necklace (Fig. 7). Dimensions of the medallion: central gold oval, 3.3x3 cm; first gold rhomb, 5.3-5 cm; second gold rhomb, 6.5-6 cm; thickness 0.38 cm; hook base, 0.4 cm; round hook, width 0.4 cm, diameter 0.36 cm; two small hooks, weight 0.22 cm; width of circle hooks on the outer rhomb, 0.4-0.45 cm, diameter 0.2-0.25 cm. The oval center and four drop-like gold cassettes have been probably decorated by enamel (not preserved). The first rhombic belt has been decorated with 4 big pearls (1 missing) of a round to barrel shape (dimensions 0.55x0.60 cm; 0.55x0.68 cm; 0.68x0.72 cm). All of them display moderate to distinct signs of dissolution. The second rhombic belt has been decorated by 12 violet sapphires (1 missing and one replaced by a reddish violet garnet) (previously published as

Fig. 7. Gold medallion with violet sapphires, garnet and pearls

Fig. 8. Gold medallion with violet sapphires and pearls; back side, detail

Fig. 9. Gold earcap N1 with emeralds and garnets

Fig. 10. Gold earcap N2 with emeralds and garnets

amethysts – Totev, 1986; 1993; Atanasov, 1999a; 1999b; *The Preslav Treasure*, 2007, 10, Fig. 1.5). The sapphire is identified by the strong red luminescence in the LW light (absent in the garnet). In most of the sapphires are identified inclusions of fine rutile needles. In a single case, in the largest sapphire, are observed inclusions of a red colour with a tetragonal prismatic to pseudoisometric crystal habit. Such ruby-red prisms are attributed to rutile crystals and are identified among sapphires from Sri Lanka (Gübelin, 1979). The violet gems are all rounded polished with a barrel or irregular shape (dimensions from 0.55x0.42 cm up to 0.65x0.68 cm). Several of them are broken around the hole. Observed are also three cases of repair – gold wire with a violet stone has been added later. All gems are drilled from both sides lengthwise and in 2 cases are observed initiations of 2 holes in other directions (Fig. 8). The third outer rhombic belt is composed by 21 pearls (10 missing). Their shape is barrel to irregular slightly baroque.

Emeralds, garnets, sapphires and pearls in a pair of gold earcaps

The maximum length of the jewellery objects are 9.5 and 10 cm correspondingly (Inv. N3381.7; weight 52.60 g). The width of the gold cassette in a crescent shape is 4 cm, with corresponding thickness 0.36 and 0.29 cm (Figs. 9-10).

Gold earcap N1. "Front" side of cassette – two emeralds (oval cabochon shape, polished; 0.75x0.50 cm and 0.6x0.4 cm) and a garnet

(round cabochon, 0.5x0.6 cm) in the middle between them. On the "back" side is observed a reverse arrangement – two reddish violet gems and between them a rectangular emerald cabochon (0.75x0.45 cm). The left reddish violet gem is a garnet (~0.5x0.5 cm) (previously all the violet gems are published as amethysts – Totev, 1986; 1993; Atanasov, 1999a; 1999b; *The Preslav Treasure*, 2007, 11, Fig. 1.8). The right violet gem (0.70x0.37 cm) has an intensive red fluorescence, fine "silk" rutile inclusions and is identified as a sapphire. On the gold wire are mounted two emeralds (0.50x0.53 cm and 0.55x0.45 cm) of fine green colour and transparency, with prismatic transparent inclusions. The rest reddish violet gems are identified as garnets (dimensions ~0.7x0.6 cm). The number of preserved pearls is 21 (6 missing) with dimension up to 1.07x0.84 cm. Most are grayish in colour and decomposed. In a single case a pearl displays a pale blue fluorescence.

Gold earcap N2. "Front" side of cassette – two emeralds (oval cabochon shape, polished; 0.60x0.45 cm and 0.60x0.55 cm) and probably a garnet (missing) in the middle between them. On the back side – reverse arrangement – two round and irregular in shape cabochon reddish violet garnets (0.60x0.45 cm and 0.60x0.45 cm) and between them an oval emerald cabochon (0.60x0.45 cm). On the gold wire pendants – two emeralds (0.54x0.54 cm and 0.71x0.67 cm) of fine green colour and transparency. The inclusions are prismatic transparent with a gas-liquid phase, as well as with some mica. The number of pearls is 27 with dimension ranging 0.44x0.98 cm. Most are grayish in colour and decomposed. In three cases pearls displays a light blue fluorescence.

Gold bilateral necklace decorated with cloisonné enamel medallions, pearls, rock crystal and amethyst beads

The two sided gold necklace (Fig. 11) is composed of a wide gold band of fine gold chains and 7 gold platelets decorated with enamel, seven drop-shaped enamel medallions and 11 pendants decorated with gold beads, pearls, rock crystal and amethyst beads (*The Preslav Treasure*, 2007, 8-9, Fig. 1.2; Inv. N2281.1; dimensions ~22x30 cm; weight 227.75 g). On the central enamel platelet is an image of the Virgin Mary. The quartz beads are rounded and slightly elongated (Fig. 12). Three of them – in the center, are of rock crystal and the rest 4 (3) beads (a pair on both sides; one missing) are of amethyst. The amethyst beads are polished better than the rock crystal beads (also with cracks). One of the amethyst beads is of best dark violet colour and in another one the colour is partly violet and partly non-coloured because of the sectorial distribution of the colour, typical for the different sectors in amethyst quartz (usually positive and negative rhombohedra) (Fig. 13). Amethyst is a known in ancient times and as it is a wide spread gem material in different genetic type of deposits (Kostov, 1992), no specific speculation about its origin can be made. The pearls are of a baroque or barrel shape (dimensions 3.5x5.5 mm) and are partly decomposed. The pearls with a white colour display fluorescence.

Rock crystal intaglio in a gold setting

The rock crystal (Fig. 14a-b) is cut in a truncated octagonal pyramidal shape (1.5x1.2 cm on base) and placed in a gold setting of the same shape (*The Preslav Treasure*, 2007, 15, Fig. 1.23; Inv. N3381.36; length 2.8 cm, width 1.9x1.5 cm; weight 12.25 g). Small triangular facets and striations are observed in the upper part. On the base are carved two figures of the Holy Mother and Archangel Gavrail (scene of Annunciation). The image is deep in cut, but not well finished. The rock crystal is quite transparent without visible inclusions.

Rock crystal faceted bead

The rock crystal bead (Inv. N3381.22; dimensions 1.74x1.51x1.31 cm) has been faceted with 14 facets to form a specific decorative shape, and later on all of them being slightly rounded (Fig. 15). The diameter of the hole, drilled lengthwise from both sides of the

Fig. 11. Gold necklace decorated with cloisonné enamel, pearls and quartz beads (rock crystal and amethyst)

Fig. 12. Gold necklace, detail: rock crystal barrel shaped bead and pearls

Fig. 13. Gold necklace, detail: amethyst bead with zonal colour and pearls

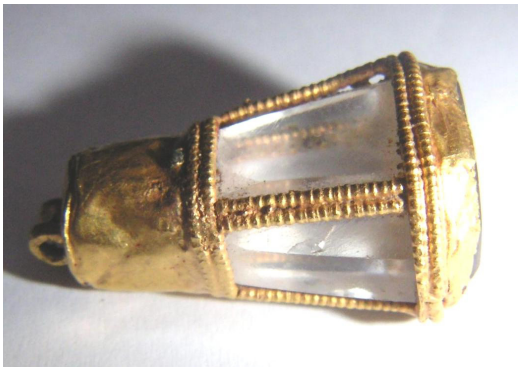

Fig. 14a-b. Rock crystal intaglio in gold setting

Fig. 15. Rock crystal faceted bead

Fig. 16. Ancient carnelian intaglio in a gold ring

bead, across its length is 0.2 cm. The refractive indices of the gem correspond to quartz (1.54). It displays no luminescence. The rock crystal is quite clear, without visible inclusions.

Carnelian intaglio in a gold ring

The oval intaglio is inset in a gold ring (Inv. N3381.15, weight 5.38 g). The carnelian gem (length 1.8 cm; Fig. 16) is engraved with an image of Hermes, probably of the antiquity period (III c. AD). It has been previously published as garnet (Totev, 1983; 1986; Atanasov, 1999a; 1999b; *The Preslav Treasure*, 2007, 13, Fig. 1.15). The surface is not well polished.

Pearls in pair of gold earcaps

A pair of big oval shaped gold earcaps (Fig. 17) composed of granular gold wire with pearl decorations (*The Preslav Treasure*, 2007, 11, Fig. 1.6; Inv. N3381.5; dimensions length to maximum width 12.3x5.2 and 12.0x5.3 cm; for the pendant part 4.4 and 4.0 cm; weight 64.60 g). In one of the earcaps is preserved a leaf shaped central medallion with a cross of pearls. The diameter of the pearls is ranging 2.5-3.5 mm, the largest of them 5.4x4.3 mm. They are irregular in shape, slightly baroque. One pearl in the first earcap and 7 pearls in the second earcap display a weak fluorescence.

Fig. 17a-b. A pair of gold earcaps decorated with pearls

Pearls in a single gold earcap

This is a single gold earcap of a pair (*The Preslav Treasure*, 2007, 11, Fig. 1.7; Inv. N3381.6; dimensions length 10.5 cm, width 4.5 cm; weight 24.85 g), similar in the gold technique and decoration to the previous case, but with a ring-type band (Fig. 18). The composition of four-ring pendants is 2.5 cm in length (three pendants of this type). Five of the largest pearls show a weak fluorescence.

Pearls in a single gold earcap

This is a single preserved double sided gold earcap (*The Preslav Treasure*, 2007, 12, Fig. 1.9; Inv. N3381.8; dimensions length 10.7 cm, width 4.7 cm; weight 42.2 g). It is composed of a cassette, a round medallion (with an image of a peacock) and three pendants, all of them with cloisonné enamel decorations (partly preserved on the back side) (Fig. 19). The pearls are of a gray to dark gray colour, baroque shaped, with decomposed outer layers and dimensions 1.5x1 to 4.5x2.5 mm.

Pearls in a single gold earcap

This is also a single double sided gold earcap or ornament (Fig. 20) with enamel (Inv. N2819; dimensions length 5.4 cm; maximum width 4.5 cm; thickness 0.56 cm). Four pearls are preserved.

Two round gold medallions or decorations with pearls

These two gold objects (both outer diameter 2.3 cm, inner diameter 1.6x1.7 cm) are not part

Fig. 18. Gold earcap with pearls

Fig. 19. Gold earcap with pearls and cloisonné enamel

of the Preslav treasure, but were found in different places at and around the king's palace (Fig. 21). The images are of a peacock (Inv. N1295) and a lion (Inv. N3637). Small pearls (dimensions 2.1 and 2.5x1.5 mm) are arranged on a gold wire in the circle belt. All pearls have fluorescence under LW ultraviolet light.

Discussion

Origin of emeralds in Antiquity and Early Medieval jewellery

Emeralds are mentioned in the first "mineralogy" of Theophrastus (IV c. BC), but in antiquity under the name of "smaragdus" usually are referred different green minerals or aggregates (rocks) – for example the "smaragdus" from Cyprus is probably malachite, and the Bactrian or Laconian "smaragdus" is turquoise or porphyry (Kostov, 2006). Pliny the Elder (I c. AD) in his "Natural History" has placed emerald as third rank after diamond and pearl. He mentions 12 kinds and sources of emerald ("smaragdus") in antiquity of which the main are Scythian (?), Bactrian (probably turquoise), from Egypt and Cyprus (probably malachite), mentioning also beryl: "Beryls, it is thought, are of the same nature as the smaragdus, or at least closely analogous; India produces them, and they are rarely to be found elsewhere; the lapidaries cut [use the natural habit of] all beryls of an hexagonal form" (Pliny the Elder, 1991, Book XXXVI, Ch. 16-18, 20). It is supposed that the use of emerald as a gemstone is introduced in Rome in the middle of I c. BC, following the campaign of Pompey (Rapp, 2009).

The oldest emerald mines in the world are

Fig. 20. Gold earcap or decoration with pearls and cloisonné enamel

Fig. 21. Two gold appliqués with small pearls

found in SE Egypt near the Red Sea – they are known as the "mines of Cleopatra", but the mineral is known also in ancient India. The famous medieval encyclopedic scientist al-Biruni (X-XI c.) wrote in his unique "Collection of Knowledge on Gems" about 4 types of emerald according to colour and perfection, citing also al-Kindi (IX c.), another famous philosopher with contributions to gemmology (al-Biruni, 1963). He mentions Egypt as the only source of emeralds, which have been traded to the East, but he also mentions a similar to emerald gemstone from India which has been traded to the West – the hard "sabandan". In the works of the Arab historian and geographer, al-Masudi (X c.) are mentioned also the four kinds of emeralds, as well as the fact that the same quality of emeralds as the Egyptian (even harder and heavier) has been mined in India (in the Sindana region) and traded to the West through Aden, Yemen and Mecca (Maçoudi, 1950, 43-49). Some of the old Indian emeralds may in fact be from Afghanistan (Morgan, 2007, 128) or in a broader sense from the Hindu-Kush area in central Asia (there are different genetic types of emerald deposits both in Afghanistan and Pakistan, which are not studied comparatively and in relation to other world emerald deposits).

Pearls and emeralds become popular about the II c. BC and in some museums are preserved pieces of ancient jewellery with emeralds (Higgins, 1980). Emerald is very rare as a raw material in glyptic art during the antiquity period.

The emeralds from the gold necklace from Oplontis (dating from the I century AD), Vesuvian Area, Naples, Italy have been studied using non-destructive methods such as Electron Probe Micro Analysis (EPMA) and microFTIR (Fourier Transform InfraRed) (Aurisicchio et al., 2005). Optical and physical gemmological tests were performed on the 19 hexagonal

emerald prisms, with average dimensions between 9.8-8.9 mm (minimum) and 14.7-9.8 mm (maximum). All had been drilled length-wise to form the necklace. Reference samples, from mines known to be active in the Roman Imperial period, were collected and analyzed using the same techniques. Experimental data were also statistically treated in order to classify the emeralds' mines. The comparison of archaeological and reference data allowed to hypothesize, with high probability, an Egyptian origin (El Sikait) for the Oplontis emeralds even if the Habachtal mine cannot be definitively excluded. Of the same age is another gold and emerald necklace found at Scafati, from the Naples Museum, including also pearls (Sinkankas, 1989, 16, Fig. 1-6). Jewellery with emeralds is known also from the III c. AD (bracelet) in Tunis (British Museum) and from the III-IV c. AD (crystal beads) in the Paris Museum – in both cases with pearls and sapphires (Higgins, 1980, Pl. 59A, 61).

The gold treasure of Guarrazar (VII century AD), found during the XIX century in Spain, is an important illustration of the high level of Visigothic jewellery in the Iberian Peninsula. The votive crowns and crosses of this treasure are an arrangement of pierced gold in a Byzantine-Germanic style, decorated with emeralds, garnets, sapphires and other gemmological materials (Guerra et al., 2007). The combination of Particle-induced X-ray emission (PIXE) and Particle-induced gamma-ray emission (PIGE) was used to analyse the gold samples and an exploitation of south Iberian mines has been suggested. A number of 11 emeralds inlaid in items from the Guarrazar jewellery that is kept in the National Museum of Middle Ages, Paris, France have been also analyzed with a suggested use of European sources (Habachtal area, Austria) unknown to the Romans (Calligaro et al., 2000).

Among the almost 500 principal gemstones of the gold altar (IX century) of the Basilica of St. Ambrose in Milan are several emeralds: one measurement – length 15.60 mm, width 13.59 mm (Superchi, 1988, 86, Fig. 11). They are of a pale colour, semitransparent and characterized as of the "root" type. Some of them display an absorption spectrum typical for chrome. They are all mounted in their hexagonal shape on one prismatic side, and in a single case – on the base. No mention was been made on the possible origin of emeralds. Visible are cracks almost perpendicular to the prismatic zone.

Twelve gemstones set into the cover of an elaborately decorated leather-bound manuscript, the Tours Gospel, 'Evangelia Quatuor', the early IX century Carolingian palette, held in the British Library (Add. MS. 11848), were identified by Raman microscopy to be composed of quartz, amethyst, emerald (probable, 3), iron garnet (3) and sapphire (3), one not being identified (Clark, van der Weerd, 2004; Clark, 2007).

Among the most important objects in the Vienna Treasury is the imperial crown (X century, Germany) decorated with sapphires from Sri Lanka, amethysts, garnets and inferior in colour and full of inclusions dark green emeralds of no suggested origin (Niedermayr, 1988, 48-50). In the gemmologically tested two pieces of emerald from the "Alb" (XII century, Palermo), decorated with different gems (including also sapphires, spinels, amethysts, garnets and opal, mostly with an Indian origin) at the same museum, are identified hornblende needles in the first case and negative crystal polyphase inclusions perpendicular to the c-axis in the second case with suggestion for an Indian (Ajmer) origin (Niedermayr, 1988, 48, Figs. 2-4). The author argues that as most of the precious minerals used during the Early Medieval ages have an Indian (and particular Sri Lanka) origin, the emeralds must have the same origin.

The famous Khakhuli triptych (XII century) in Georgia (State Museum of Fine Art) is a fine example of artistic metalwork decorated with gem minerals, numerous pearls and cloisonné enamels *(The Khakhuli Icon,* 1979). Among the gem and decorative minerals are sapphire, ruby and/or spinel, emerald, garnet, quartz (rock crystal and probably amethyst) and turquoise. Emeralds are in a

rounded rectangular, square or pear (triangular) shape setting, usually decorating cross-shape ornaments (Figs. 17, 36, 42, 44, 54, 57, 62, 83, 89, 91, 97, 99).

Emeralds are known from the crown of St. Heinrich (c. 1280) with precious stones at the treasury of the Bamberg Cathedral (Gübelin, 1988, 118, Fig. 4). Among the collection of jewels in the Residence Palace in Munich are also some cut "cloudy" emeralds of a possible Egyptian origin (Gübelin, 1988). Some of the prismatic emerald crystals are of the observed longest prismatic shape compared to the previous cases.

Emeralds from Bulgaria

Contemporary and former Bulgarian lands have a rich history according to gem materials and techniques from the prehistoric period (Kostov, 2007) to the antiquity and Middle Ages period (Kostov, 2006). Emeralds have been reported from two different occurrences in Bulgaria (Urdini Ezera in the Rila Mountain and Yugo-vo in the Central Rhodopes) during the second half of the XX century (Petrussenko, Kostov, 1992) and there is no evidence that they have been known and exploited in earlier times.

Comparative investigation in Bulgarian museums among Antiquity and Early Medieval jewellery has displayed several cases of objects with emeralds. In the Archaeological Museum of the National Archaeological Instutute at the Bulgarian Academy of Science on display are a gold necklace and earrings with emeralds from a family Roman treasure found at Nikolaevo (Pleven District) from the I-IV century AD (Filov, 1914). The dimensions of the short hexagonal prismatic dark green, nearly non-transparent emeralds beads, which are well polished at their edges are about 1.2x0.55, 0.8x0.9 and 1.2x0.9 cm. Similar in shape and polish are the prismatic emerald beads from the gold jewellery (an about 22-25 cm long necklace; earrings; a iron and gold hair-pin) from ancient Ratiaria (now Archar, Vidin District) from the Roman Province of Moesia Inferior: 0.9x1.0, 1.2x1.0, 1.3x0.9, 1.1x1.0 and 1.0x1.0 cm. In both cases it seems that the emerald beads are of one and same origin.

A rare gold Early Christian reliquary decorated with an emerald (?), sapphires and garnets from the V or early VI c. AD is on display in the Varna Archaeological museum (Inv. NIII-767; Minchev, 2003, 16-18). From the Roman period (I-III century AD) in the same museum is a set of gold earrings with hexagonal prismatic emerald beads (4 of probably 8 beads preserved) found in ancient Odessos (now Varna) or in the region (Doncheva, 2003, 13).

Among the treasures (now at the State Hermitage Museum in St. Petersburg, Russia) of the founder of Old Great Bulgaria – Khan Kubrat (VII century), are a gold ring and a gold bracelet with insets of emeralds of unknown origin (see Kostov, 2006).

Some possible sources: Egypt, Austria and Central Asia

The genetic types of emerald deposits have been reviewed in a number of monographs and papers (Kievlenko et al., 1982; Sinkankas, 1989; Kostov, 2003; Groat et al., 2008). The listed and new archaeomineralogical studies suggest at the presence three possible sources of emeralds in Antiquity and Early Medieval jewellery – Egypt, Austria and Pakistan (Giuliani et al., 2000; Rapp, 2009). A study on the origin of emeralds in Mogul objects from the Iran Treasury in Teheran (Meen, Tushingham, 1968) and at the State Hermitage Museum, St. Petersburg (Strack, 2008) confirms their later Colombian origin.

Despite the fact, that emeralds have been found in a lot of other countries in Europe and Asia during the last century, it is possible that some single pieces (from placers) could have been found and used in earlier times. In Europe despite Austria and Bulgaria, emerald deposits or occurrences are known also from Ukraine (Lavrinenko et al., 1971), Spain – Franqueira (Martinizard et al., 1995), Russia – Ural Mountains (Vlasov, Kutukova, 1960; Kievlenko et al., 1982; Gromov et al., 1990;

Laskovenkov, Eliezeri, 1998) and Norway – Byrud (Eidsvoll) (Nordrum, Raade, 2006). In Asia emeralds have been found in Kazakhstan (Chernikov, Dorfman, 2004; Gavrilenko et al., 2006), in the Panjshir valley, Afghanistan (Bowersox et al., 1991; Bowersox, Chamberlin, 1995; Sachanbinski et al., 2003), in China (Blauwet et al., 2005) and in India mainly in the state of Rajasthan (Bagchi, 1958; Gupta, Mathur, 1987; Sinkankas, 1989; Biswas, 1994) (for world reviews see, Sinkankas, 1989; Morgan, 2007; Groat et al., 2008).

Different analytical methods have been used in order to distinguish the origin of emeralds and their genetic type of deposit: optical spectroscopy measurements (Wood, Nassau, 1968; Platonov et al., 1978; Gromov et al., 1990); different type of inclusions (Gübelin, 1979; Gromov et al., 1990), oxygen isotope composition (Giuliani et al., 1998a; 1998b; 1999; 2000), laser-induced luminescence (Moroz et al., 1999), Raman microspectroscopy and fluorescence (Moroz et al., 2000), Electron Probe Micro Analysis (EPMA), Fourier Transform InfraRed (microFTIR) spectroscopy (Aurisicchio et al., 2005) and Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) (Abduriyim, Kitawaki, 2006) (for reviews see, Sinkankas, 1989; Groat et al., 2008).

Egypt. Emeralds are found at the boundaries of schist and granite or related to the quartz veins and granite pegmatites in Southern Egypt (Grubessi et al., 1989; Sinkankas, 1989; Jennings et al., 1993; Abdalla, Mohamed, 1999; Harell, 2004; 2006; Grundmann, Morteani, 2008). The preliminary study of four principal mine areas in the Sikait-Zubara region has confirmed emerald exploration during a long period of time – from the Ptolemaic period at Gebel Sikait to the XVI century at Gebel Zubara (including the Byzantine and Ottoman periods) (Shaw, 1999; Shaw et al., 1999; Aston et al., 2000). Beryl mining is been especially active during the Early Roman (I – middle of II c. AD) and the Late Roman (IV – early VI c. AD) periods (Harell, 2006). Two examples are given for beryl from the Roman period – a statue decorated with beryl from the Cairo Museum and a gold necklace from the Yale University Art Museum (Aston et al., 2000). Necklaces with emerald, quartz (rock crystal and amethyst) and amazonite beads from Egypt (probably I c. AD) are illustrated by Kunz (1971, 20a, 36a). Supposed beryl in the jewellery from the pre-Ptolemaic period turned out to be amazonite or olivine (Lucas, Harris, 1962). The Egypt deposits have been considered for a long time as the only source for emerald in the Mediterranean region in the Hellenistic Period.

Austria. The Habachtal emeralds are known since the publication of C. M. B. Schroll in 1797 and of J. Frischholz in 1821 on the geology of the area: they are found as porphyroblasts in biotite-epidote-plagioclase gneiss and metasomatically altered serpentinites during a two-stage process of metamorphism (Morteani, Grundmann, 1977). The emeralds are usually with a core full of inclusions – biotite, chlorite, apatite and epidote. The mineralogy and geology of the emerald deposit are described in a number of publications (Leitmeier, 1937; Gübelin, 1956; Grundmann, Morteani, 1982; Sinkankas, 1989).

Pakistan. The Pakistan emerald deposits are related to two geological setting: to pegmatites and to metasomatic alteration of the ophiolithic mélange to a talc-dolomite schist (*Emeralds of Pakistan,* 1989), but the origin of emerald is still very controversial. Emerald occurs at a number of localities in northwestern Pakistan and has been studied from different point of view (Carbonnel, 1976; Gübelin, 1982; Rafiq, Qasim Jan, 1985; Kazmi et al., 1986; Bowersox, Anwar, 1989; Sinkankas, 1989; Gromov et al., 1990; Arif et al., 1996). The largest of the emerald deposits are those near the town of Mingora and the village of Gujar Kili, Swat valley. The region is being regularly mined and has been producing some of the world's finest quality gemstones for more than 40 years.

As at the present stage no analytical including oxygen isotope data is available on

the emeralds from the Preslav gold treasure, their origin is discussed on the base on their morphology, internal features and inclusions. The two-phase inclusions as negative crystals and mica inclusions are shown to be characteristic to Indian emeralds from the Ajmer-Mervara region (Gübelin, 1979). Similar inclusions are found on emeralds from XII c. "Alb" from Palermo, with a suggested Indian origin (Niedermayr, 1988). An alternative may be some genetic type of emeralds from the Hindou-Kush area (Afghanistan and Pakistan).

Origin of violet sapphire and garnet

Pliny (I century AD) writes about blue and violet sapphires, of which the best are supposed to be the Median (Pliny the Elder, 1991). Pale blue, pinkish or violet blue sapphires are common in Early Medieval jewellery. Garnets from different sources have been used also since predinastic times in Egypt and traded on a larger scale since the Hellenistic period in antiquity (Rapp, 2009). Among the principal gemstones of the gold altar (IX century AD) of the Basilica of St. Ambrose in Milan are also several pale violet blue sapphires (with red luminescence under UV light, inclusions of rutile needles and negative crystals) with a suggested origin from Sri Lanka (Superchi, 1988, 78). The crown of Queen Kunigunde of Lorraine (made c. 1010-1020 AD) is supposed to be set with rounded cabochon sapphire beads from Sri Lanka (Gübelin, 1988). Combined external-beam PIXE and μ-Raman characterization of garnets used in Merovingian jewellery (V-VII century) has revealed that up to the end of the VII century AD this gemmological material of a predominant almandine and rhodolite composition is traded correspondingly from India and Sri Lanka (Farges, 1998; Calligaro et al., 2002). As the Indian subcontinent has been the main source of precious corundum in Antiquity and Early Medieval times, it can be assumed, that the violet or reddish violet gems in the Preslav treasure are of an Indian and/or Sri Lankan origin.

Remarks on pearls

Pearls are used in jewellery since the antiquity period and they have been traded widely in the Mediterranean region, as well as Central and South Asia in the Early Medieval period (Strack, 2006). The pearls from the Preslav treasure are barrel-shaped or baroque-shaped. Some of them are partly decomposed, with a gray colour and they do not display any luminescence. The mean values for length/diameter are close – 0.40/0.45 cm in the case of the medallion with emeralds. Probably the Byzantine jewellery masters have received pearls from the Indian Ocean and the Persian Gulf. The most important pearl-producing bivalve mollusks in the area are *Pinctada radiata* and *Pinctada margaritifera*. During the IX century relations were established between the oriental trading centres and some European cities – Venetian trading companies had offices in Aleppo and Constantinople (Strack, 2006, 148).

Conclusion

The gem minerals and pearls of the Preslav gold treasure (X century; adornments from gold decorated with enamel, beads of gem minerals and pearls: diadem, bilateral necklace, medallions, several earrings and earcaps, rings, buttons, appliqués and other small finds) have been studied by their morphometric and gemmological features. Among the gem minerals are identified 40 emeralds, 12 violet sapphires, 10 reddish violet garnets, 5 rock crystals, 3 amethysts and 1 carnelian. Their inclusions and type of cut and polish are listed. The average dimensions for the emerald polished and rounded on the edges prisms from two medallions are: length 0.48 cm and width 0.59 cm (ratio 0.81). The average dimensions for the mainly barrel shaped sea pearls from a gold medallion are length 0.40 cm and diameter 0.45 cm (ratio 0.88). The origin of the emeralds is under discussion (Egypt, Austria), and they are compared with other emerald finds in Europe, including from Bulgaria, from the Antiquity and Early Medieval period. At the present stage of knowledge, according to their

inclusions, the gem minerals (sapphire, garnet) are supposed probably to come from the area of Indian subcontinent (including Sri Lanka). An alternative may be the Hindou-Kush area. The pearls are supposed to origin also from the East – the Persian Gulf and the near-coast areas of the Indian Ocean. Listed are ancient and medieval sources for trade of the mentioned minerals from India to the East, as well as contemporary studies by modern methods, which are in support of the idea for their origin.

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