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Characterization and provenance of ancient gemstones: Case study of a gold-and-sapphire jewel dating from the Roman imperial period and found in a tomb in Colonna, Italy

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***Abstract* – In 2011, an extraordinary piece of gold jewelry set with precious stones was found in a woman's tomb discovered not far from Rome and dating from the third century AD. Our examination and archaeometric analyses enabled us to identify the technique used to make the jewel and to characterize the nature and provenance of the gemstones. The analyses showed that all the stones were natural sapphires. Their inclusions and gemmological features indicate that they came from southern and south-eastern Asia, thus gaining insights about trade routes and the luxury-goods market during the Roman imperial period.**

I. INTRODUCTION

In 2011, a preemptive archaeological investigation was carried out at Pian Quintino, an area on the outskirts of the town of Colonna, on the north-eastern slopes of the Alban Hills, a few kilometres south-east of Rome (fig. 1).

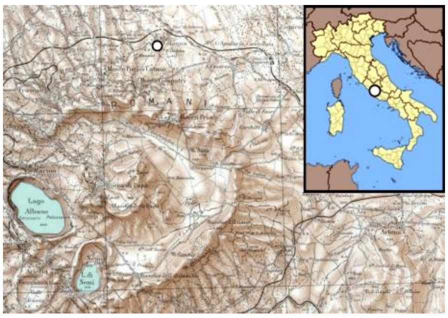

Fig. 1. Map showing the Alban Hills and the location where the jewel was found.

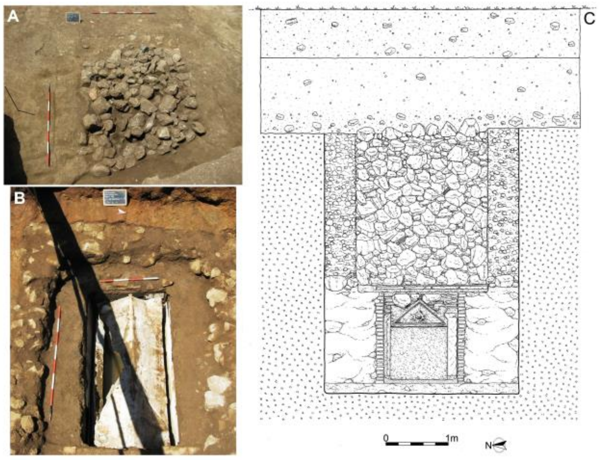

Fig. 2. The monumental tomb discovered in Colonna. A: Top of the masonry core, viewed from above. B: The funerary chamber and the sarcophagus inside it. C: North-south cross-section drawing of the tomb.

This area was already well known to archaeologists. A good number of protohistoric and archaic settlements and burial sites were discovered here in recent times [1-2]. Several settlement sites dating from the Roman republican and imperial periods have also been discovered; they were probably related first to *Labicum quintanensis*, and later, in the mid-imperial period, to *Ad quintanas* [3-5]. Both these towns are mentioned in ancient sources, e.g. Livy (*Ab Urbe Condita* 4, 47) and Strabo (*Geographica* 5, 237). They also appear on ancient maps: according to the *Tabula Peutingeriana,* for instance, *Ad Quintanas* was located at the 15th mile of the Via Labicana [6].

The investigation carried out along a road named Via Valle della Chiesa led to the discovery of part of a necropolis (eleven graves) dating from the Roman imperial period [7]. The tombs were located alongside an ancient stone-paved road, probably the Via Labicana [5, 8]. This funerary area included a monumental tomb which has been dated to the mid-third century AD [7]. It consists of a rather complex underground structure which may have been topped above ground by an altar. Without dwelling on the details, it consisted of a rectangular pit about 4.5 m deep (fig. 2), at the bottom of which was a small chamber with brick walls faced with marble slabs and sealed with terracotta tiles. The chamber housed a white marble sarcophagus (fig. 2:B, C), probably Proconnesian [7]. The space above the chamber had been filled with stones mixed with earth and mortar to form the masonry core of the mausoleum.

Fig. 3. The female skeleton inside the sarcophagus, after the clay fill was removed. Enlarged images of the jewel (1) and of the gold-thread fabric (2), as they were found.

The lid of the sarcophagus had cracked some time after the burial, allowing water to seep in and deposit layers of fine clay. A microstratigraphic excavation conducted inside the sarcophagus itself uncovered the skeletal remains of the person who had been laid in it: a woman about 40 years old and 155cm tall (fig. 3). A few but valuable grave goods had been buried with her: a silver ring, a bone handle (maybe related to a fan), and a gold jewel set with precious stones (fig. 3:1). A certain number of textile fragments were also found – probably residues of the deceased's garments – including the remnants of a border in gold-thread fabric (fig. 3:2) and of other fabrics made of organic fibers, e.g. linen or wool, and silk [7].

II. MATERIALS AND METHODS

A. Methods and analyses

All the stones were examined with a Rayner Dialdex refractometer (spot method), a MAGI GemmoRaman 532 spectrometer (Raman analysis) and Innov-X System's Omega Xpress X-ray fluorescence spectrometer (EDXRF tests). We also ran UV-VIS-NIR spectroscopy tests, using two spectrophotometers: a Pye Unicam Sp8-100 and a Jasco V-630. However, because of the jewel's fragility and morphology, these tests could not be performed in all directions. Microscopic observations were performed in order to describe the technical characteristics of the jewel and the internal gemmological features of the stones.

III. RESULTS

A. Analysis and technical examination of the jewel

Fig. 4. The Colonna jewel. A: Front and back view. B: Slanted view. C: Hypothetical reconstruction; the empty links are set with pearls, which over time may have dissolved in the acid volcanic earth.

The gold wire chain-shaped jewel, probably a diadem, was found near the skeleton's skull (fig. 3:1). It is made up of twenty-five gold links, with the smaller ones at the two ends and the others gradually increasing in size toward the middle of the chain (figs. 4-5). The chain is 29 cm long and weighs 58.72 grams.

Each link consists of two separate loops of wire (0.95 to 1.20 mm thick) that intertwine to form a Hercules knot. The knot is soldered onto a cross-shaped base made of two flat strips set along the link's two axes. The strips are 1.70 mm wide and 0.50-0.70 mm thick (fig. 6:A-B). Besides supporting the knot, the base also serves to connect the links to each other. One end of each horizontal strip forms an open hook, the other a closed ring, or eye, so that the links are connected to each other by means of a simple hook-and-eye system. A small gold sphere is soldered on top of each link joint (fig. 6: A-B).

Fig. 5. The Colonna jewel; the links are numbered from 1 to 25, the gemstones from S1 to S7.

Seven links are each set with a blue gemstone. These alternate with plain links; there three plain links at each end of the chain, then two between the stone-set links. The settings are of various kinds, according to the cut of the stone.

The first stone at each end of the chain is globular (fig. 5, stones nos. S1 and S7). Each is held in place by two gold-wire prongs welded onto the opposite ends of the short strip of the link's cross-shaped base. The prongs bend inward to fit into the hole drilled horizontally through the middle of the stone, thus securing it to the link. Similar opposing pairs of bent prongs are present in all the plain links except one (no. 12); in links no. 9 and 14, however, the prongs are welded at the two ends of the long axis.

Stones S2, S3, S5 and S5 are oval cabochons in bezel settings (fig. 5). This kind of setting consists of a bezel, or collet (the metal band that encircles the girth of the stone), welded onto a thin base plate (fig. 6: A-C) to form a box into which the stone fits snugly.

The round cabochon in the middle of the chain (stone S4, link no. 13, fig. 5) was set by means of a vertical piece of gold wire, one end of which was welded to the cross-shaped base of the link. The wire passes through the hole drilled perpendicularly through the stone; the emerging end was then hammered to form a rivet-like head which holds the stone in place. The plain link to the left of this one (no. 12) has a similar vertical "pin" with a hammered head (fig. 5), which suggests that this link too was set the same way, with a stone or other

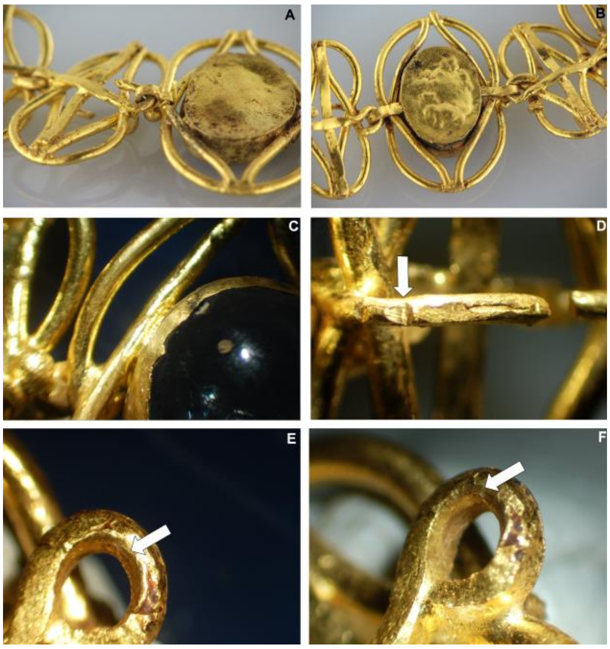

Fig. 6. Details of the jewel. A: Bottom-up view of a hook-and-eye connection between two links. B: The thin gold base plate of a bezel setting incorporates a horizontal strip that connects this link to the ones on either side of it. C: A hammered bezel, showing tiny protrusions, called burrs, caused by the hammering.D: Tool-mark left on a prong when it was bent and forced into the proper position; tiny grooves due to imperfect finishing are also visible. E-F: Wear marks on the inner surface of the eyes on the two end links, probably caused by rubbing against a metal extension, perhaps a chain.

decorative element.

The wires used to shape the Hercules knots had been carefully smoothed and polished, as is clear from the presence of pseudo-facets on their surface. Those used for the prongs, on the other hand, had not been finished, as indicated by the spiral lines on the metal (fig. 6:D).

All the prongs – whether or not the links are still set with gemstones – bear marks of forcing (fig. 6:D). These marks were left by the metal tool the goldsmith used to push the prongs into the holes drilled in the stones or other decorative elements that were set in the links and which, with the exception of the two stones at the ends of the chain, are no longer present. Since the prongs do not show any sign of having been later opened in order to remove the now-missing decorative elements, we may surmise that these elements were made of perishable materials, such as pearls (fig. 4:C). Pearls are composed of calcium carbonate, and therefore dissolve in acid environments; the famous anecdote recounted by Pliny the Elder (*Naturalis Historia* 9.58:119-121) about Cleopatra drinking a pearl dissolved in vinegar comes to mind [9]. If the diadem's missing gems were in fact pearls, they may well have dissolved over the centuries, since the volcanic earth here is acid enough to dissolve human remains as well [2, 8].

The eyes on the two end links show signs of wear (Fig. 6: E-F); this suggests that they were connected to metal-wire elements. Most likely, these missing elements made it possible to add an extension to the jewel, which is only 29 cm long. The possibility of adjusting the jewel's length may have also made it possible to choose whether wear it as a diadem or as a necklace.

As regards the gold alloy, we employed EDXRF (Energy Dispersive X-Ray Fluorescence) analysis to measure its purity in several parts of the jewel. The resulting values, including near welded areas, were between 99.7 and 99.9%, with negligible amounts of iron, copper and nickel (e.g. fig. 7:1).

B. Gemmological analysis

All the gemstones were identified as natural sapphires (a variety of corundum) (table 1). The EDXRF tests [10] detected trace elements showing that the origin of four of these sapphires (nos. S1, S2 , S4 and S7) was basaltic, that of the other three (nos. S3, S5 and S6) was not (fig. 7:2-3).

Based on the results and comparisons of the trace elements, we may suggest that the source deposits of the three non-basaltic sapphires were in Sri Lanka. Still renowned today for its flourishing sapphire trade [11], this area was the most important source for these gemstones in ancient Roman times as well [12-13]. As regards the four basaltic-origin sapphires, we suggest that their sources were in Thailand and Cambodia [14]; like the other three stones, these too would have reached

Table 1 Technical description of the seven sapphires set on the Colonna jewel (nos. S1-S7)

n.	Shape/Cut	Measures (mm)	Estimated weight	Fluorescence	Origin
1	Globular with polished surface	8.30 x 6.82 x 7.70 ca.	ct. 4.90	none	basaltic (Thailand or Cambodia)
2	Oval cabochon	11.50 x 8.85 x 5.20 ca.	ct. 5.70	very weak (reddish)	basaltic (Thailand or Cambodia)
3	Oval cabochon	12.20 x 9.70 x 3.40 ca.	ct. 4.40	none	non-basaltic (Sri Lanka)
4	Subspherical with polished surface	12.45 x 11.80 x 9.91 ca.	ct. 16.30	none	basaltic (Thailand or Cambodia)
5	Oval cabochon	11.60 x 10.00 x 4.00 ca.	ct. 5.00	weak (reddish)	non-basaltic (Sri Lanka)
6	Oval cabochon	11.50 x 7.80 x 3.30 ca.	ct. 3.20	medium (red)	non-basaltic (Sri Lanka)
7	Subspherical with polished surface	9.26 x 7.70 x 8.32	ct. 6.70	none	basaltic (Thailand or Cambodia)

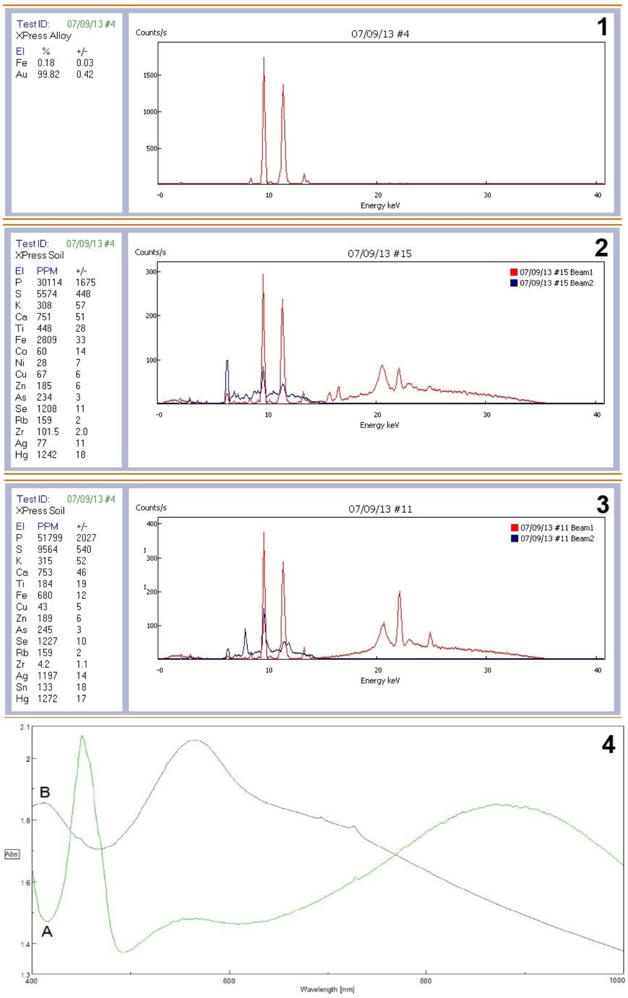

Fig.7. Archaeometric analyses. 1. Results of the EDXRF test conducted on a link of the Colonna jewel. 2. Results of the EDXRF test conducted on one of the four sapphires found to be of basaltic origin. 3. Results of the EDXRF test conducted on one of the three sapphires found be of non-basaltic origin. 4. Comparison between the UV-VIS spectra of two of the jewel's sapphires. Line A refers to the basaltic stone, line B to the non-basaltic one.

Rome after travelling long trade routes [12], since trades and contacts are documented [15]. We may also consider the Massif Central, in France, as a possible source [16]. During the Middle Ages this deposit yielded sapphires of remarkable gem quality, and its exploitation in Roman times cannot be ruled out.

As we show in fig. 7:4, our hypotheses about the stones' provenances are supported by the results we obtained – albeit with some difficulty due to the stones' settings – with UV-VIS spectroscopy [17-18].

Moreover, except for sapphire S2, the diagnostic features we observed when we viewed the stones under a microscope (figs. 8-9) seem to confirm their provenance from these geographic areas [19-21].

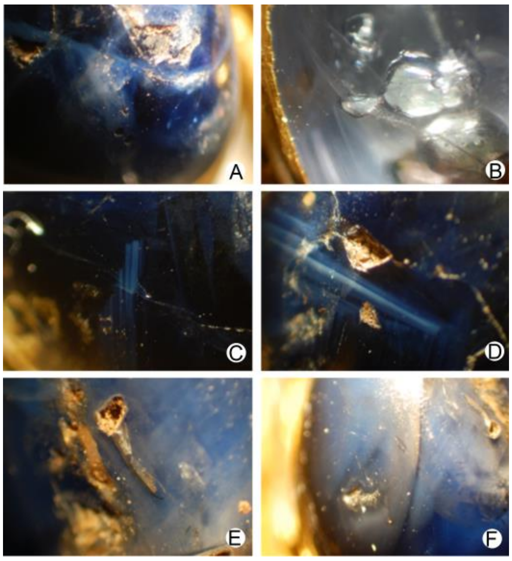

Fig. 8. Details of the inclusions in the four basaltic-origin sapphires. A: Colour zoning, fractures and cavities filled with debris. B: Large negative crystals. C: Colour and growth zoning, whitish bands of very small crystalline inclusions. D: Debris-filled cavity, colour and growth zoning, whitish bands. E: Cavities and elongated debris-filled negative crystal. F: Cavities, colour and growth zoning. These photos were taken at different magnifications (20x - 40x); scale not available.

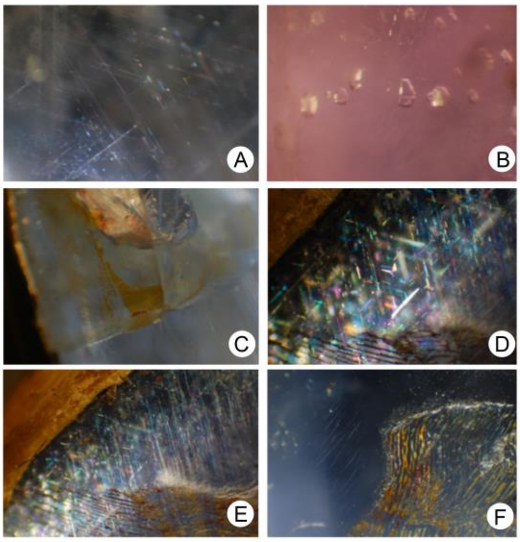

Fig. 9. Details of the inclusions in the three non-basaltic-origin sapphires. A: Crossed needle-like inclusions. B: Multi-phase negative inclusions. C: Fracture with traces of oxidation, and large negative crystal. D: Crossed needle-like inclusions. E: Crossed needle-like inclusions, and fingerprint inclusions. F: A fingerprint inclusion on the right; fire marks caused by overheating during polishing are visible on the left, on the gem's surface. These photos were taken at different magnifications (20x - 60x); scale not available.

IV. CONCLUSIONS

In ancient Rome, sapphires were highly prized as very rare and valuable gems. They were rather scarce during the last centuries of the Roman Republic; their numbers increased during the imperial period, but they temporarily declined during the third century AD, due to the difficult political situation of the time [13].

Unfortunately, Latin sources don't provide any information that would help us identify the provenance of sapphires in Roman times. This is due in part to some confusion in terminology. For example, the gemstone that Pliny called *sappirus* (*HN* 37.38 and 37.39) was probably lapis lazuli; the true sapphire (a variety of corundum) was known to the ancients by the name *hyakinthos*, or hyacinth stone [13].

The trade route followed by sapphires and other gemstones from south and south-east Asia to Rome probably started from the Indian Ocean coast [12] (cf. also Pliny, *HN* 37), went up the Persian Gulf, then overland to the eastern Mediterranean. Sapphires and pearls are mentioned as traded commodities in the *Periplus Maris Erythraei*, written about AD 40 [12]. They are also registered in the *Alexander Tariff*, written in the second century AD, which lists imported Eastern goods subject to customs duties in Alexandria [22].

The grave goods found in the Colonna tomb attest to the high social status of the woman buried in it. She was probably a member of an aristocratic family native to the Colonna area, or perhaps to Rome itself, since many villas are known to have been located in the vicinity [3, 5, 8]. The "Lady of the Sapphires", as she is referred to today, was wealthy enough to obtain expensive goods present on the international market. The gold-thread fabric [23] and the Proconnesian-marble sarcophagus [24] point to contacts and trade with the rich eastern-Mediterranean markets. The silk fabric and the sapphires indicate that, during the imperial period, exotic luxury goods reached Rome by way of transcontinental trade routes. Silk came from China [25] and sapphires, based on gemmological characterizations, from Sri Lanka, and probably from Thailand and Cambodia as well.

The unusual design of the Colonna jewel may have been conceived by the goldsmith to set certain gemstones that were already available to him. This gold-and-sapphire chain, which may have been worn both as a diadem and as a necklace, could be of eastern Mediterranean origin (Syriac area). The Hercules-knot motif and the large sizes of the stones – most of them cabochon-cut – reflect the taste of Roman ladies of the third century AD [26].

As regards the stones, the closest comparable jewel is a large gold bracelet set with sapphires, emeralds, blue glass and now-missing pearls, dated to 250-400 AD and now in the J. Paul Getty Museum (inv. 83 AM 227.2) [27]. Based on its colour and internal features, the Getty bracelet's blue-sapphire cabochon has been attributed by the gemmologist J. Koivula to Sri Lankan deposits [13].

The total weight of the sapphires mounted on the Colonna chain is estimated at 46.2 carats (cf. tab. 1). This too seems to be a unique feature (no comparable case in ancient Greek or Roman jewellery is known), a fact that further emphasizes the importance and wealth of this extraordinary Colonna tomb.

V. ACKNOWLEDGEMENTS

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