The Talisman of Charlemagne: New Historical and Gemological Discoveries

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The gem-bearing reliquary known as the Talisman of Charlemagne is closely associated with the history of Europe. Its legend follows such figures as Charlemagne, Napoleon I, Empress Josephine, Hortense de Beauharnais, Napoleon III, and Empress Eugénie. This study provides new historical information collected in France, Germany, and Switzerland about the provenance of this exceptional jewel, which contains a large glass cabochon on the front, a large blue-gray sapphire on the back, and an assortment of colored stones and pearls. The first scientific gemological analysis of this historical piece, carried out on-site at the Palace of Tau Museum in Reims, France, has made it possible to identify the colored stones and offer insight into their possible geographic origins. Based on our data and comparison with similar objects of the Carolingian period, we propose that the blue-gray sapphire is of Ceylonese (Sri Lankan) origin, that the garnets originate from India or Ceylon, and that most of the emeralds are from Egypt except for one from the Habachtal deposit of Austria. The estimated weight of the center sapphire is approximately 190 ct, making it one of the largest known sapphires as of the early seventeenth century.

The Talisman of Charlemagne is a sumptuous jewel that has passed through the centuries. At various times it has been said to contain fragments of the hair of the Virgin Mary and a remnant of the True Cross. It is therefore a reliquary, a container in which sacred relics are kept. Its globular shape resembles that of a pilgrim's small bottle or eulogy ampulla, which were filled with earth or liquid from a holy place (Gaborit-Chopin and Taburet, 1981; Scordia, 2012). The talisman's romantic fate is intertwined with many historical figures involved in its passage through Germany, France, and Switzerland. This first gemological characterization was conducted during two rounds of analysis, lasting one day each, in May 2017 and June 2018.

HISTORICAL BACKGROUND

Origin of the Talisman of Charlemagne. As the origin of the reliquary has been lost in the mists of time since the Carolingian period, it is difficult to specify the circumstances of its creation. Charlemagne died in the imperial capital of Aachen (known as Aix-la-Chapelle in French) on February 28, 814 CE. Since the emperor did not leave specific instructions, his entourage decided to bury him in Aachen Cathedral (Minois, 2010). The talisman was believed to have been suspended from a necklace worn on Charlemagne's body in his tomb, though it has not been possible to prove this. Eginhard (770–840 CE), in his biography *Vita Karoli Magni* (*The Life of Charlemagne*), written shortly after the emperor's death, does not mention the reliquary. While the talisman's characteristics are slightly different from the works that can be dated with certainty to the reign of Charlemagne, considering the shape of the jewel and its typical Carolingian goldsmithery (gold buttons, palmettes, filigree, and *repoussé* work), the experts on this period, De Montesquiou-Fezensac (1962) and Gaborit-Chopin and Taburet (1981), attested with confidence a dating to the middle to late ninth century (i.e., just after the reign of Charlemagne, excluding any forgery).

The exhumation of Charlemagne conducted in the year 1000 by Otto III, the Holy Roman Emperor, was chronicled by Thietmar, bishop of Merseburg around 1012–1018:

> Ignoring the exact place where the bones of Emperor Charles lay, [Otto III] secretly broke the ornamental tiling of the church where they were supposed to be,

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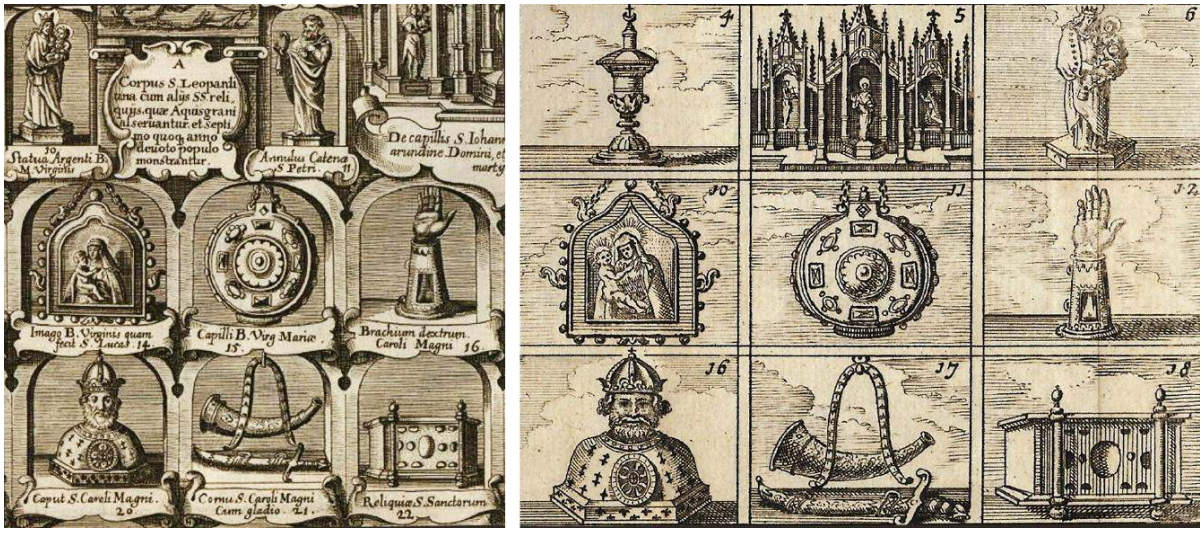


Figure 1. Details of two engravings, published by Gerhard Altzenbach (left, British Museum, Q5.375, 1664) and from Jacobus Harrewijn (right, 1711), both representing the treasury of Aachen Cathedral. A stylized Talisman of Charlemagne appears in the center, as number 15 (left engraving) and number 11 (right engraving). Represented on the right engraving: (4) a piece of the rope with which Jesus was bound, (5) a piece of the Holy Cross, (6) a statue of the Virgin Mary, (10) a portrait of the Virgin Mary according to St. Lucas, (11) hairs of the Virgin Mary, (12) the right arm of Charlemagne, (16) St. Charlemagne's bust, (17) his hunting horn and sword, and (18) relics of the sanctuary.

> then dug until discovering them in a royal sarcophagus. He took for himself the golden cross that hung around the corpse's neck and a part of his not yet putrefied clothes; after which he put everything back in place with the utmost respect. (Thietmar of Merseburg, 2001)

This text is too imprecise to establish a link with the reliquary. The body of Charlemagne was exhumed again in 1166 for his canonization by order of the Holy Roman Emperor Frederick Barbarossa (Gobry, 1997). Once again, no information was given about a reliquary.

The list of relics of Aachen was mentioned in manuscripts written circa 1200, based on original documents from the ninth century. While the original documents have been lost, some elements of these secondary sources have been copied in more recent manuscripts deposited at the Berlin State Library and the University of Bonn in Germany (Quix, 1840; Schiffers, 1937). We find in particular the mention of the hair of the Virgin Mary.

The booklet of the relics of Aachen (Montesquiou-Fezensac, 1962), *Heiltumsbüchlein* in German, was produced circa 1520. Intended for the pilgrims, it is more accurate and does mention a reliquary: *Quoddam cleinodium, continens de capillis et lacte beatae Mariae Virginis* ("A precious jewel, container of hairs and milk of the Saint Virgin Mary"). This brief description of the "precious jewel" could correspond to the Charlemagne reliquary, during a period when the preserved relics were much more important than the reliquary itself.

It was not until the seventeenth century that engravings of the reliquary began to appear. One of the first was by Abraham Hogenberg, in Noppius (1632), in which the talisman was shown with the other relics from the treasury of Aachen Cathedral. The engraving is accompanied by the words *Capilli B. virginis Mariae*: "the hair of the Virgin Mary." Later engravings of the relics, especially by the engravers Gerhard Altzenbach (1664) and Jacobus Harrewijn (1771), were reproduced in various works during the seventeenth and eighteenth centuries. On all of these engravings the talisman is stylized, with a center stone surrounded alternately by four faceted stones and four cabochons (figure 1). Pearls, which appeared in later engravings between each stone pair, are not visible. Pöllnitz (1736) also gave an illustrated representation. Subsequent descriptions are more precise, as in de Barjolé (1786), who notes: "The hair of the Blessed Virgin. They are enshrined in a Golden Reliquary, lined with precious stones."

Early Nineteenth Century: From the Reliquary to the "Talisman of Charlemagne." During the French Revolution (1789–1799), the relics from Aachen Cathedral were taken to the German city of Paderborn.

After the revolution, Aachen became the administrative headquarters of the Roer department in 1802 and acquired French status. Relics that had been displaced in 1794 were restored to Aachen Cathedral (Kleinclausz, 2005). Napoleon, crowned emperor on May 18, 1804, considered himself the heir to Charlemagne and decided to visit the tomb of his great predecessor. Empress Josephine preceded him to Aachen in July 1804. In August, Marc-Antoine Berdolet, nominated bishop of Aachen by Napoleon two years earlier, offered the emperor the reliquary (Minois, 2010). Newspapers of the time such as the *Moniteur*, the *Gazette de France*, and the *Journal du Commerce* attest to this gift, as does a message written by the bishop and addressed to the empress dated 23rd Thermidor, year XII (i.e., August 11, 1804). An excerpt reveals the presence of

> a small round reliquary made of pure gold adorned with stones, the bulb of which contains relics, and the large stones in the middle contain a small cross made of the wood from the holy cross. These two small reliquaries were found around the neck of St. Charlemagne when his body was exhumed from his sepulcher in 1166, and history tells us that Charlemagne was accustomed to wear these same relics during battles. (Lohmann, 1924)

This message suggests that at the time the talisman preserved several relics.

From this point on, the relevant texts no longer mention the Virgin Mary's hair in the reliquary. It is therefore possible that between 1801 and 1804 the bishop had removed all or part of the relic and replaced it with a small wooden cross consisting of two fragments—supposedly from the True Cross—fastened by a thread. An examination carried out in the 1960s by Bernard Gomond, a specialist in ornamental trimmings, identified the thread as raw Tussar silk from India, used between the late eighteenth and late nineteenth centuries.

The rest of the reliquary's history is much more precise. After her divorce from Napoleon, Josephine de Beauharnais remained its custodian (Ollivier, 1897). The talisman was her personal property and not part of the crown jewels of France. At Josephine's death in 1814, her daughter, Hortense de Beauharnais, inherited the talisman. Hortense's memoirs, written during exile after the fall of the Empire, described the reliquary:

> My mother had gone to take the waters at Aachen.… The Emperor, on his arrival in the city, was received with the greatest enthusiasm. The city was grateful to him for having brought back the relics which, since Charlemagne, had made the glory of Aix-la-Chapelle. The chapter and the city believed they could not better prove their gratitude than to offer to the one whom they regarded as a new Charlemagne an object which had belonged to their glorious founder. It was a talisman that Charlemagne always wore in combat and that was still found at his collar when his tomb was opened in the year.… I still possess all these objects.

Besides being Napoleon's stepdaughter, Hortense was also the emperor's sister-in-law following her marriage to Louis Bonaparte, king of Holland (r. 1806–1810). As such, she became the guardian of the Napoleonic legacy.

At the Arenenberg estate on Lake Constance in Switzerland, Hortense received many visitors, including Alexandre Dumas père (Baylac, 2016). In his 1833 book *Impressions de voyage en Suisse*, which includes historical chronicles, a journey log, and ethnological considerations, the great writer describes the reliquary. This is the first known use of the term *talisman* for this object:

> It is now the Talisman of Charlemagne; this talisman has quite a story; lend your ear. When the tomb in which the great Emperor had been buried was opened at Aachen, his skeleton was clothed in his Roman clothes, and his talisman, which made him victorious, was suspended from his neck. This talisman was a piece of the True Cross sent to him by the Empress. It was enclosed in an emerald, and this emerald was suspended by a chain to a large ring of gold. The citizens of Aix-la-Chapelle gave it to Napoleon when he entered their city, and Napoleon, in 1813, tied this chain round the neck of Queen Hortense, confessing to her that, the day of Austerlitz and of Wagram, he had carried it on his breast, as Charlemagne had done nine hundred years ago.

In Brief

- The Talisman of Charlemagne is a sumptuous jewel covered in gemstones and dating to the middle to late ninth century, just after the reign of Charlemagne.
- Using portable spectroscopy equipment, the authors characterized the 29 gemstones and propose that all but one of the almandine-pyrope garnets originated from southern India or Ceylon, while all but one of the emeralds were from Egypt and the sapphires were from Ceylon.
- The substitution of the front center gemstone by the cobalt-doped glass cabochon probably occurred in the late eighteenth century and certainly before 1843.
- The center sapphire has an estimated weight of 190 ct and can be considered the largest sapphire used in European jewelry during the Early to High Medieval period.

Figure 2. Felix Cottreau's 1834 portrait of Hortense de Beauharnais, wearing the talisman with the front side facing out. This scene put the spotlight on the talisman, which most certainly was never modified to be worn as a cloak clasp. Courtesy of Napoleon Museum Thurgau.

This romantic description of the talisman by Dumas contributed to its mystery and notoriety. Nineteenth-century texts on the origin of the talisman must be regarded with caution, but these beliefs about the amulet were shared by the imperial family (Paléologue, 1928).

The Napoleon Museum in the castle of Arenenberg preserves an 1834 portrait by Felix Cottreau of Queen Hortense "wearing" the reliquary as a cloak clasp (figure 2). Instead of the chain we know today, the reliquary depicted on this painting is connected to several elements, including two ovals adorned with gems and a cloak clasp, a clothing fastener commonly used in the eighteenth and nineteenth centuries in place of buttons. These elements are most certainly the fruits of the artist's imagination, since no other representation or description of the talisman reports that it was modified to be worn as a cloak clasp, and since the present-day regular chain appears in the previous seventeenth and eighteenth centuries engravings (again, see figure 1).

The Talisman of Charlemagne from Napoleon III to Today. Queen Hortense passed down the Arenenberg estate and its possessions to her son Prince Louis Napoleon Bonaparte, the future Napoleon III. Sentenced to life imprisonment following his failed coup attempt in 1836, he was a prisoner at Fort de Ham in the Somme until 1846. After selling the Arenenberg castle in 1843, he also sought to sell precious objects such as the reliquary. In a letter to his first cousin, Prince Jerome Napoleon, he valued the reliquary at 150,000 francs (Guériot, 1933), though the sale did not go through (Maison, 1991). A drawing of the reliquary signed by Prince Louis Napoleon (figure 3) dates from this period. The text above the drawing is a rewritten copy of the 1804 description by Berdolet, the Bishop of Aachen. Below the talisman is an updated characterization of the center stone as a "rough sapphire" with a "very light color," as translated below:

> Talisman of Charlemagne, which antique dealers believe was sent to Charlemagne by the Empress Irene [of Constantinople, 752–803 CE]. This talisman was given to the Emperor Napoleon at Aix la Chapelle by the Clergy as attested by the above copy of the Bishop's letter. The middle stone is a rough sapphire and has a very light color.

A year later, an engraving of the reliquary appeared in the newspaper *L'Illustration* ("Talisman de Charlemagne," 1844). The article contained inaccurate rumors that had been circulating since the beginning of the nineteenth century, namely that Charlemagne "constantly wore" the talisman and that the Abbasid caliph Harun al-Raschid had given it to him:

> The drawing above represents, in its natural size, an object of immense interest, both archeologically and religiously. It was the talisman that Charlemagne constantly wore on him, which was found hanging around his neck when his sepulcher was opened in 1166, and which was given to Emperor Napoleon by the clergy of Aix-la-Chapelle on the 23rd Thermidor Year XII… At the end of the eighth century, there were only two great sovereigns in the world, Charlemagne and Haroun-al-Raschid… it was offered with the keys of the holy sepulcher.

The exchange of diplomatic gifts with the East was a common practice in the Carolingian period. Charlemagne and the caliph are said to have exchanged several ambassadors, but no archival source authenticates the gift of this jewel. Nevertheless, several newspapers reproduced this account and the engraving, including the *Illustrated London News* in 1845 and *The New Illustrated* in 1866. A more complete article was written by Sir Martin Conway for *The Antiquaries Journal* in 1922.

Prince Louis Napoleon became Emperor Napoleon III and grew attached to the talisman, keeping it until his death in 1873. During the Second French Empire, from 1852 to 1870, it resided in his room in the Tuileries Palace (Clouzot, 1925). A reliquary box was even made for it in 1855 by the Parisian goldsmith Froment-Meurice. In 1866, Charles Clément, deputy curator at the Louvre, appraised the reliquary at the emperor's request. His appraisal indicated that three stones were missing: one emerald and two pearls (Taralon, 1966). That same year, the note was reproduced with engravings (realized from three photos taken in 1866 and provided by Napoleon III) by the German historian and archaeologist Ernst Aus'm Weerth (1866; see figure 4, bottom):

> This reliquary, preserved in the Treasury of Aachen, was offered by the city of Aix-la-Chapelle with other relics to Emperor Napoleon I during the coronation. He then presented it to Empress Josephine. At her death it passed to Queen Hortense, and now belongs to her [Josephine's] grandson Napoleon [III]. Two large sapphire cabochons, one oval and the other square, enclose a cross made of wood of the true cross; it is only seen on the side of the oval sapphire. It is invisible on the side of the rough cabochon.

At the fall of the Second French Empire in 1870, the talisman's pedigree remained unclear. Some believe it was hidden in a subterranean passage connecting the two houses of Baugrand, the crown jeweler, in Etretat (Lindon, 1949). According to the Duke of Alba, the empress handed the talisman to a Dr. Conneau, who hid it in a wall of his house. The doctor was later able to return it to the empress in England. Napoleon III was known to keep it in his bedroom while in exile (Anceau, 2008). A painting by George Goodwin Kilburne depicts this room, where the emperor met his death in 1873. The painting's precision makes it possible to identify certain details such as the reliquary box crafted in 1855 by Froment-Meurice. Empress Eugénie, the widow of Napoleon III, resisted the solicitations of Kaiser William II to return it to Aachen (Maison, 1991). Moved by the fire of the Cathedral of Reims during World War I, she donated it before her death to the Archbishop of Reims, Cardinal Luçon, on the advice of Dom Cabrol, Abbot of Farnborough (Taralon, 1966). In Paléologue (1928), she recounts this episode:

> This talisman, I held it as the apple of my eyes; I had it near my bed while I was giving birth to the Imperial Prince. But since 1879, since I no longer have a direct heir, a question arose for me, a question which troubled me very much: After my death, what would become of the relic? Many times, under one pretext or another,

Figure 3. A drawing believed to be from 1843 or 1844, showing the front of the reliquary, with a copy of the description by Berdolet, the Bishop of Aachen (1804), and an inscription by Prince Louis Napoleon (later Napoleon III). Courtesy of Napoleon Museum Thurgau.

the Archbishop of Cologne and the Chapter of Aix-la-Chapelle had begged me to restore it to the Carolingian treasury: I had obstinately refused. Then, in my lifetime, I thought of giving it to Pope Leo XIII, in memory of Pope Leo III, by whom Charles was crowned emperor, in the basilica of St. Peter, in front the tomb of the Apostles, Christmas night 800… But I have reflected that sooner or later the people of Cologne and

> Aix-la-Chapelle would obtain from an accommodating Pope the restitution of the jewel; for strictly, theologically, there is no prescription for relics… So I was very perplexed when the war of 1914 broke out. The horror of the bombardment of Reims suddenly illuminated me. One fine morning I exclaimed: "It is at Reims that I shall leave the Talisman of Charlemagne, and it will be the punishment for the barbarians!" I had, beside me, the person most capable of advising me in this respect, the very erudite Abbé de Farnborough, Dom Cabrol. He studied the legal means to accomplish the donation and managed to find formulae such that in no event could the French government, the Archbishop of Reims or even the Holy See ever remove the Talisman from the reliquary of our kings. Cardinal Luçon having acquiesced in all the clauses, Dom Cabrol handed over to him last Sunday the famous pendant.

The reliquary was turned over to Cardinal Luçon by Dom Cabrol on November 30, 1919, according to Daudet (1922) in *L'inconnue*. With the gift, the following statement was issued:

> The formal wish of the Empress is to give to the Cathedral of Reims, in reparation for the outrages it suffered during the war 1914–1918, of this relic and the reliquary which contains it, so that they remain forever the property of the church of Reims, with the duty for the Archbishop of Reims to take whatever measures he deems necessary to achieve this end.

The empress died the following year in Madrid. In her will, she bequeathed 100,000 francs for the reconstruction of the Cathedral of Reims. In 1927, the reliquary became the property of the Diocesan Association of Reims. It was classified as a historical monument in 1962 and deposited five years later in the treasury of the Palace of Tau in Reims, where it remains on permanent display. In 1964, the famous goldsmiths Lucien and Jean-Claude Toulouse restored the talisman under the supervision of Jean Taralon, General Inspector of Historical Monuments. During the restoration, two missing pearls and one emerald were replaced, as indicated by Taralon (1966). All known photos of the talisman taken thereafter, by Henri Graindorge (1964), Hélène Guillot (1964), Claude François Garnier (1965), and Louis André and Denis Cailleaux (1985), present the talisman in its current form and with the same small chain (seen in figures 3 and 4). Unfortunately, the only photographs from before the restoration, taken in 1866 and circa 1915 by Henri Deneux, lack sufficient resolution to show the missing stones.

METHODS OF ANALYSIS

It is only rather recently that items of historical jewelry have been analyzed on-site using spectroscopic methods that are portable and compact (Häberli, 2010; Barone et al., 2014; Jeršek and Kramar, 2014; Reiche et al., 2014; Farges et al., 2015). Often these are the only analytical methods possible when cultural treasures cannot be moved from their location, such as a museum or historical site. The drawback is that the results are not as complete as those that could be obtained in the laboratory or on unset stones.

For the Talisman of Charlemagne, we used conventional gemological tools: electronic balance, microscope, polariscope, and ultraviolet lamp. Due to the stones' size and position in the setting, their refractive indices could not be determined. To gain additional data, we further analyzed the talisman using portable spectroscopic techniques, namely Raman scattering and visible/near-infrared (Vis-NIR) optical absorption spectroscopy at room temperature. We used two compact Raman spectrometers (Ocean Optics QE 65000) with 532 and 785 nm laser excitation. The absorption spectrum in the visible to near-infrared range (400–1000 nm) was recorded with an Ocean Optics USB2000 spectrometer. A Niton XL3T GOLDD+ portable X-ray fluorescence (XRF) analyzer was used to estimate the chemical composition (elements heavier than Na) of the various gemstones using a 3 mm collimator. The predefined "mining" setup mode and the NIST610 and 612 glass standards were used as references to control the calibration. It must be mentioned that quantification of Mg by XRF can be challenging, as its detection limit is quite high. The average detection limits of the analyzed elements were: 6500 ppmw Mg, 2500 ppmw Al, 1500 ppmw Si, 110 ppmw Ca, 100 ppmw Co, 85 ppmw Mn, 60 ppmw Ti, 45 ppmw Ba, 35 ppmw Cr, 35 ppmw Fe, 35 ppmw V, 20 ppmw Au, 10 ppmw Pb, 5 ppmw Y, 5 ppmw Ga, and 3 ppmw Rb.

RESULTS OF THE ANALYSIS

Macroscopic Observations. The talisman is a gold reliquary, in the form of a eulogy ampulla, composed of two circular parts joined together by a band of gold. It measures 6.5 cm wide, 7.3 cm tall, and 3.50 cm in thickness (the thickest point at the centers of the two center stones). The surface includes filigree and *repoussé* work. Its total mass is 160.45 g (an estimated 7 g from the chain). The front side is dominated by a large bluish cabochon surrounded by nine colored stones (numbered V1 to V9 in figure 4) alternating with eight pearls. This is the face most often seen in artistic representations of the talisman. It is also the face that reveals by magnifying effect through the cabochon the supposed fragments of the True Cross mounted in the shape of a cross. The reverse side

Figure 4. Left to right: Present-day photos of the front, back, and side of the talisman (top) compared with engravings (bottom) from Ernst Aus'm Weerth (1866). V1, V3, V5, V7, V9, S1, S3, S7, S9, P1, and P9: pyrope-almandine garnet. S5: grossular garnet. V2, V4, V6, V8, S2, S4, S6, and S8: emerald. P2, P4, P6, and P8: sapphire. P3, P5, and P7: amethyst. A pearl is set between each colored gemstone. Photos by G. Panczer.

shows a large bluish gray polished stone with a "sugarloaf" shape, again surrounded by nine colored stones (S1 to S9 in figure 4) alternating with pearls. The side of the talisman is also set with nine colored stones, numbered P1 to P9. The small stones are mainly polished as cabochons and have various shapes such as oval, round, diamond, pear, or free-form. Only two stones are faceted: Dark red S1 on the back has four facets, while violet P3 on the side has an oval table. Most of the green stones present polished natural prism faces. All the pearls have the peculiarity of being drilled. Their original setting consisted of a gold crimp pushed inside the drill hole. This is the case for all the pearls except the one between P3 and P4, which presents a bezel setting and has a clearly visible drill hole. We presume that this is one of the two replacement pearls that were added with an emerald during the restoration of the talis-

Figure 5. Reflected light (left) and transmitted light (right) reveal an abundance of bubbles in the glass cabochon. In both photos, the wooden cross and the silk thread are clearly visible. Photos by G. Panczer.

man in 1964 (Taralon, 1966). The second replacement pearl is on the front of the talisman, located between V8 and V9 (figure 4). It was missing on the photo presented in the report of Taralon (1966) and appears much whiter than the others.

Microscopic Observations. Observation of the center cabochon on the front of the talisman revealed the presence of numerous bubbles, which are characteristic for artificial glass. In addition, the sacral relic was clearly visible when viewed in transmitted light (figure 5). This relic consists of two fragments of wood tied together in the shape of a cross. The center stone on the back of the talisman (figure 6) contained numerous fissures (visible in brightfield illumination through the cabochon), unaltered healing fissures, and parallel tubes of fluid inclusions and brown inclusions (possibly mica). No needles could be observed in the large center stone. The smaller colored stones set in the talisman are relatively opaque and did not reveal characteristic inclusions. The green stones have a characteristic hexagonal prismatic shape and fingerprint textures that indicate beryl.

Figure 6. A composite image from four magnified photos of the large center sapphire (38 × 32 mm) on the back of the reliquary, seen through a trinocular microscope in transmitted light. Photos by G. Panczer and M.S. Krzemnicki.

Spectroscopic Results. *Sapphires.* The gray to bluish stones (P2, P4, P6, and P8) were identified by Raman spectroscopy as corundum with various background fluorescence levels (P6 and P8). The polished center sapphire on the back of the talisman was also unambiguously identified by its Raman spectrum as corundum. XRF analysis revealed weak amounts of Fe (565 ppm), Ti (116 ppm), and Ga (68 ppm), while Cr was not detected (table 1). This center sapphire showed an absorption spectrum (figure 7) typical for

TABLE 1. Trace-element concentration (XRF) of the talisman's center sapphire and four small sapphires (average of P2, P4, P6, and P8).

	Center sapphire		Small sapphires	
	Avg. (4 spots)	Standard deviation	Avg. (4)	Standard deviation
Fe	565	66	817	220
Ti	116	16	153	40
Ga	68	6	64	14
Cr	bdl	—	bdl	—
Mg	bdl	—	bdl	—
V	bdl	—	bdl	—

bdl = below detection limit

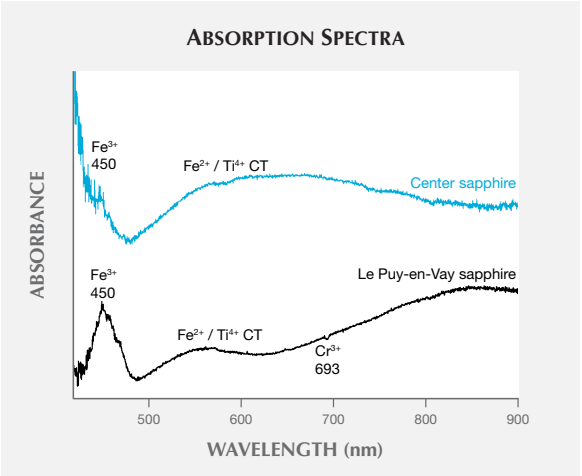
TABLE 2. Trace-element concentrations (ppmw) of seven of the talisman's eight emeralds compared to those of other beryls from early deposits (Habachtal, first to thirteenth century CE; Djebel Zabara, first century BCE to sixth century CE; Swat, first century BCE to third century CE; and Panjshir, thirteenth century BCE).

	Talisman of Charlemagne	Habachtal (Austria)		Djebel Zabara (Egypt)		Swat (Pakistan)		Panjshir (Afghanistan)	
Source	This work	Calligaro et al. (2000)	Aurisicchio et al. (2018)	Calligaro et al. (2000)	Aurisicchio et al. (2018)	Calligaro et al. (2000)	Aurisicchio et al. (2018)	Calligaro et al. (2000)	Aurisicchio et al. (2018)
Number of samples	7 Standard dev.	13	3	6	2	4	3	5	3
Analytical technique	XRF	PIXE	EPMA	PIXE	EPMA	PIXE	EPMA	PIXE	EPMA
Fe	4518 (958)	4000	3316	4600	6024	6230	10390	2080	1632
Cr	3689 (1672)	1390	945	2600	3224	5930	6635	2650	1458
V	454 (324)	170	145	330	300	320	433	970	1774
Ti	76 (75)	30	4	7	60	10	40	12	120
Rb	10 (5)	18	n.m.	24	14	6	3	30	33

n.m. = not measured

metamorphic sapphires (Smith, 2010), with a broad absorption band (550–700 nm) assigned to Fe^{2+}/Ti^{4+} intervalence charge transfer and a very small absorption peak at 450 nm caused by the presence of some trivalent iron (Fe^{3+}). For comparison, figure 7 also shows a typical absorption spectrum for basaltic sapphire from Le Puy-en-Velay in the Haute-Loire region of France, a potential source of sapphires for European medieval jewelry. Its spectrum exhibits a very different absorption behavior, with a marked Fe^{3+} peak at 450 nm and a general increase in absorption toward the near-infrared range, a pattern very characteristic for such basaltic sapphires (Fritsch and Mercer, 1993; Krzemnicki et al., 1996). Based on this, we conclude that the sapphire in this talisman is of metamorphic origin. Moreover, we did not observe a Cr^{3+} emission line at 693 nm. This was confirmed by the total absence of red fluorescence under long-wave UV illumination (365 nm). We could not record the absorption spectrum of the other sapphires because of their small size and their position in the setting. Their chemical composition was similar to that of the main center sapphire (table 1).

Figure 7. The absorption spectrum of the talisman's center sapphire, obtained with diffuse reflectance, compared to that of a representative sapphire from Le Puy-en-Velay in the Haute-Loire region of France. Here, CT represents charge transfer.



Emeralds. The Raman spectra of the green beryls on the front (V2, V4, V6, and V8) and back (S2, S4, S6, and S8) exhibited an intense background fluorescence that did not allow the detection of characteristic vibration modes. XRF analyses were conducted on all beryls except V2 and S2, for which the setting was too close to the stone's surface. The chemical results corresponded to beryl, and a high average Cr content confirmed that they are emeralds (table 2).

Garnets. Raman spectrometry is well suited for identifying members of the garnet group (Pinet and Smith, 1994; Kolesov and Geiger, 1998). Most of the talisman's small red stones (V and S, numbers 1, 3, 5, 7, and 9) show characteristic spectra of the almandine-pyrope solid solution series $(Fe,Mg)_3Al_2(SiO_4)_3$, with a major Fe-rich almandine component (figure 8). Only brownish red S5, on the back of the talisman, appears to be an almandine-grossular garnet (figures 4 and 8) and V1 a Mg-rich pyrope-almandine. Beside those two garnets, XRF analyses confirm that the others presented an $Alm_{91–46}Py_{0–42}Gr_{4–27}Sp_{1–6}$ compositional range of the continuous series (table 3).

TABLE 3. Composition of garnets in the Talisman of Charlemagne, as determined by XRF analysis.

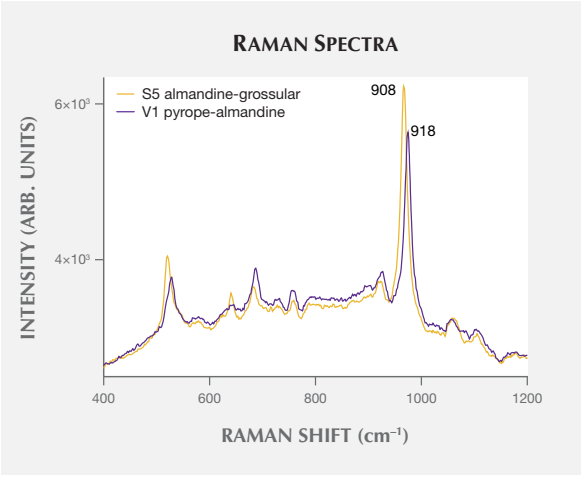
	Almandine (mol.%)	Pyrope (mol.%)	Spessartine (mol.%)	Grossular (mol.%)	Cr (ppmw)	Standard deviation	Y (ppmw)	Standard deviation
S7	91	0	4	4	53	66	450	23
V3	72	16	6	5	815	76	613	26
S5	70	0	3	27	216	60	6	5
S3	55	33	2	10	bdl	—	53	8
S9	48	37	2	13	158	54	15	5
S1	47	41	1	11	155	51	8	4
V7	46	40	1	12	164	45	bdl	—
V5	46	42	2	11	369	48	8	4
V9	41	47	2	10	bdl	—	12	5
V1	29	55	1	16	402	43	67	7

bdl = below detection limit

Amethysts. The Raman spectra of the violet stones (P3, P5, and P7; not shown) identified them as amethyst quartz.

Glass Cabochon. Under 785 nm excitation, the center cabochon on the front side reveals a broad intense luminescence band at a Raman shift of 1375 cm^{-1}, which corresponds to an 880 nm fluorescence band (figure 9). When excited with a solid state 532 nm laser, its spectrum was dominated by broad Raman bands and Q2 and Q3 modes (again, see figure 9) characteristic of partially depolymerized sodic glass (Raffaëlly et al., 2008).

Figure 8. Raman spectra (785 nm excitation) of the representative pyrope-almandine garnet V1 (purple line) and the almandine-grossular garnet S5 (orange line) in the talisman.



The absorption spectrum of the glass cabochon showed characteristic absorption bands (542, 597, and 644 nm) of divalent cobalt Co^{2+} (Lima et al., 2012) and a transmission domain at 480 nm, which explains the cabochon's blue color (figure 10). As cobalt is a very strong chromophore and the cabochon's color is not very saturated, it is not surprising that the Co concentration was below the detection limit of XRF while the chemical composition was 81 wt.% SiO_2, 10 wt.% PbO, 7 wt.% K_2O, and 2 wt.% CaO. Under long-wave UV illumination (365 nm), it exhibited intense blue fluorescence, which could be caused by Bi^{3+} traces (Xu et al., 2012).

Pearls. The pearls' composition did not present any Mn and Ba traces; both were below the XRF limit of detection.

Gold Setting and Chain. XRF analysis of the gold setting showed that the jewel is made of nearly pure gold: 92.5 wt.% Au, 5 wt.% Ag, and 2.1 wt.% Cu, which corresponds to 22K gold. The chain composition is quite different: 77.1 wt.% Au, 20.8 wt.% Ag, and 1.1 wt.% Cu, which corresponds to 18K gold.

INTERPRETATIONS AND DISCUSSION

Because the talisman's gems have different cuts, we can speculate that they were recovered from various ornaments or jewels. The fact that the pearls all have drill holes corroborates this hypothesis. However, the very basic styles of the different cuts allow us to suggest, as Taralon (1966) and as Gaborit-Chopin and Taburet (1981) did, that the setting of these gemstones is contemporaneous with the reliquary and thus probably from the ninth century (except for two

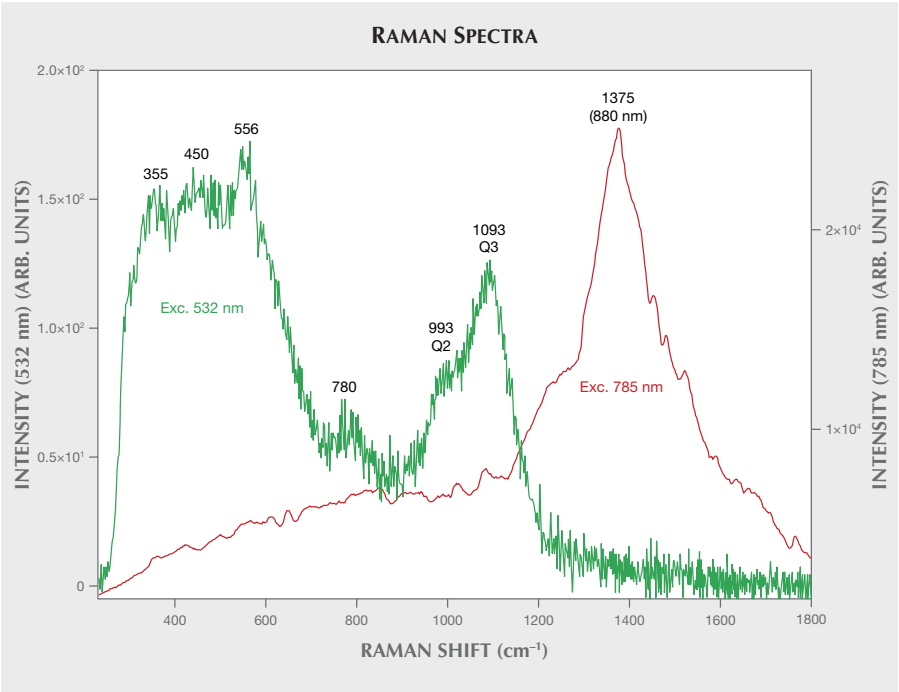
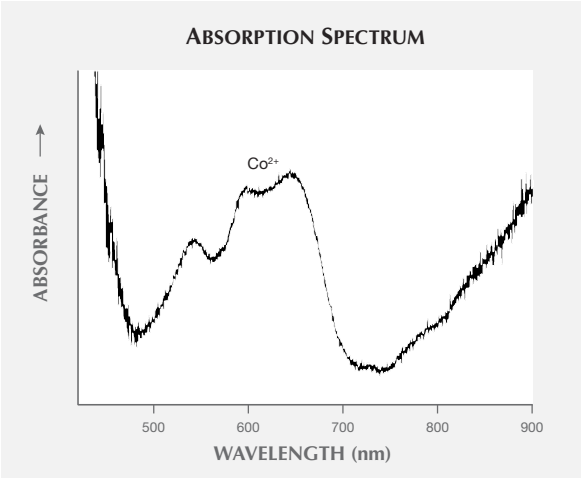


Figure 9. Under 532 nm laser excitation, the glass cabochon exhibits characteristic Raman bands of partially depolymerized glass. Under 785 nm excitation, a strong fluorescence conceals the Raman spectrum. Qn species are [SiO_4] tetrahedra with n bridging oxygen; Q2 has two non-bridging oxygen and Q3 has one non-bridging oxygen.

pearls and one emerald that were replaced during restoration in 1964).

The gold setting of the talisman is composed of nearly pure gold, as it was worked during the Middle Ages and antiquity, while the chain corresponds to a more recent alloy. According to several authors (Taralon, 1966; Gaborit-Chopin and Taburet, 1981; Scordia, 2012), the gold cable-type chain with thick round links we know today was likely added during the nineteenth century. They claim that the change had been made before the 1843 or 1844 drawing signed by Prince Louis Napoleon and the newspaper article from *L'Illustration*. Indeed, the different representations of the reliquary since this date shows a comparable chain. The painting by Felix Cottreau (1834) is not taken into account because its representation of the reliquary was modified for artistic reasons. On the older engravings of the seventeenth and eighteenth centuries, a chain is also visible. If that model is not very different from the current model, we cannot prove with certainty that the chain has been changed. The reliquary could have originally been suspended from a leather or fabric cord (Taralon, 1966; Scordia, 2012).

Figure 10. The glass cabochon's absorption spectrum shows the characteristic Co^{2+} bands at 542, 597, and 644 nm.



Concerning the pearls, the absence of Mn and Ba traces indicates a marine origin. The fact that they are all drilled confirms they were recycled from antique jewels (earring or necklace), which was commonplace.

Assumptions About the Geologic Origin of the Colored Gemstones. *Sapphires.* For the center sapphire, the inclusions do not allow an unambiguous geographical origin determination. But since the absorption spectrum we obtained corresponds to that of a sapphire of metamorphic origin, and due to the

nature of some of its inclusions, notably the elongated parallel fluid tubes and the resorbed brownish mica flakes (Hughes, 2017), it is reasonable to suggest a Ceylonese origin. Furthermore, the negligible amount of Fe, Ti, Ga, and Cr (below the XRF detection limit) and lack of fluorescence was consistent with the data of Halicki (2013) for Sri Lankan sapphire. Similar grayish blue stones are known in Sri Lanka today and would usually be heat-treated to improve their color. A French origin can be excluded, as sapphires from the Haute-Loire region are of magmatic (basaltic) origin (figure 7). A Ceylonese origin would also be consistent with other sapphires set in objects of the Carolingian period (700–1100 CE), such as those of Charlemagne's ninth-century ewer (Caplan and Notari, 2015), the Golden Tabernacle (Superchi, 1988), and the eleventh-century Crown of Cunegonde (Gübelin, 1988). The sapphires around the talisman as well as the large sapphire are characterized by a similar gray-blue to blue-gray color. In the case of the smaller sapphires, however, the impossibility of performing optical absorption spectroscopy means their origin remains unknown.

Garnets. In attempting to identify the origin of the garnets, the authors referred to the classification of Gilg et al. (2010) and Schmetzer et al. (2017). These authors classified ancient Greek, Roman, and Early Medieval garnet-bearing jewels according to five main type clusters, based on their chemical composition, and related to this the calculated percentages of the different pure end members of the pyralspite and ugrandite garnets as well as their chromium and yttrium content. Raman peak positions and chemical signatures (a major almandine component with relatively high Y concentration) indicate that almost all of the garnets set in the talisman correspond to cluster A (historical garnets originating from southern India or Sri Lanka in the Middle Ages) as described by Gilg et al. (2010) and Schmetzer et al. (2017). We therefore assume they originated from southern India or Ceylon. Garnet V1 with its different chemical composition might be of a different origin, presumably corresponding to a Bohemian garnet (cluster E, chromium-rich pyrope), a provenance also encountered in European jewelry of that period.

Emeralds. The emeralds set on the talisman all present the same characteristic chemical signature, with an average of 0.68 wt.% Fe_2O_3, 0.57 wt.% Cr_2O_3, and 0.07 wt.% V_2O_3, except for emerald S6 (figure 4) and its lower contents (0.58 wt.% Fe_2O_3, 0.18 wt.% Cr_2O_3, and 0.03 wt.% V_2O_3). These values can be compared with the data collected for emeralds from

Timeline of the Talisman of Charlemagne

742: Birth of Charlemagne (Charles the Great or Charles I), King of the Franks and ruler of the Carolingian Empire.

801: According to legend, the talisman is a gift from Abbasid Caliph Harun al-Rashid to Charlemagne.

January 28, 814: Charlemagne dies at the age of 72 in Aix-la-Chapelle. It is said that the talisman was suspended from his neck in his tomb.

1000: First exhumation of Charlemagne's body. No description of the talisman is mentioned.

1166: Second exhumation on the occasion of his canonization by Antipope Paschal III.

12th or 13th Century: A manuscript mentions a reliquary with a strand of hair of the Virgin Mary as part of the Aix-la-Chapelle treasury.

17th Century: The first engravings of the stylized reliquary, with a central stone surrounded alternately by four faceted stones and four cabochons, appear with the other relics from the treasury of the Cathedral of Aachen. One of the oldest is made by Abraham Hogenberg in the book *Aachener Chronik* by Johannes Noppius in 1632, accompanied by the words: *Capilli B. virginis Mariae* (the hair of the Virgin Mary).

August 1804: Marc-Antoine Berdolet, Bishop of Aix-la-Chapelle, gives the reliquary to Josephine de Beauharnais, who precedes the arrival of Napoleon on an imperial visit. From this date there is no longer any mention of the Virgin Mary's hair in the reliquary. It is therefore possible that all or part of the relic were removed to add two pieces of wood presented as the True Cross of Christ.

December 1809: Josephine is divorced by Napoleon, but continues to be the owner of the reliquary. Therefore it is not part of the crown jewels of France.

May 29, 1814: At the death of Josephine, her daughter, Hortense de Beauharnais, inherits the reliquary. It will stay with Napoleon's stepdaughter for the rest of her life, even during her exile in Arenenberg on the shores of Lake Constance.

historical mines worldwide such as Habachtal, Austria (first to thirteenth century CE); Swat, Pakistan (first century BCE to third century CE); Panjshir, Afghanistan (thirteenth century BCE); and Djebel Zabara, Egypt (first century BCE to sixth century CE); see Giuliani et al. (2000), Calligaro et al. (2000), Groat et al. (2014), and Aurisicchio et al. (2018). Table 2 compares the results of XRF analyses from this study with the results of Calligaro et al. (2000) by proton-induced X-ray emission (PIXE) and of Aurisicchio et al. (2018) by electron probe microanalyzer (EPMA). We assumed that the potential presence of very tiny inclusions did not interfere with the emerald composition results from the other studies. The composition of the emeralds in the talisman does not appear to correspond to those of Habachtal, which have a much higher Cr and V concentration (table 2). The chemical values are comparable to those of Djebel Zabara, which have very similar Cr and V values. Compared with the talisman, emeralds from Pakistan present a much higher amount of Cr, while those from Afghanistan much higher V. As an exception, emerald S6 shows a chemical composition (4049 ppm Fe, 1201 ppm Cr, 189 ppm V, 15 ppm Rb, and Ti below the detection limit) similar to those of emeralds from Habachtal. This emerald could be the one that was replaced by Taralon during the restoration of 1964. Unfortunately, the three 1866 photos do not represent the back face of the talisman where this emerald is located.

Our conclusion is consistent with Giuliani et al. (2000), who investigated emeralds set in jewelry prior to 1545 and found that they originated either from Habachtal or early Egyptian mines. The fact that the chemical signature of seven of our studied emeralds corresponded with Egyptian origin and one with Austrian provenance, suggests that the emeralds of the talisman were extracted much before the sixteenth century. Yet the basic fashioning of the emeralds, in the form of simply polished prismatic crystal fragments or as cabochons, is in our opinion a good indication that these stones are at least contemporary with the reliquary (Gaborit-Chopin and Taburet, 1981). We therefore assume that most of the emeralds of the talisman originate from Egypt (except emerald S6, see above) and not from Austria, as often expected for historical emeralds of this age.

Amethysts. The origin of the amethysts in the talisman is unknown. A number of quartz deposits in the crystalline massifs of Saxony were already known and exploited by the Middle Ages (Scordia, 2012). At the same time, the recycling of even older (ancient) amethysts, originating from Egyptian mines such as those of Wadi el-Hudi, southeast of Aswan, could be a possibility in this context (Liszka, 2018).

1832: In his book *Impressions de voyage en Suisse*, Alexandre Dumas mentions the reliquary and calls it a "talisman." This is the first time the term is used to describe it.

1834: Felix Cottreau's portrait, housed in the Napoleon Museum Thurgau, of Queen Hortense bearing the reliquary.

October 5, 1837: When Queen Hortense dies, she passes down the Arenenberg estate to her son, Prince Louis Napoleon (later Napoleon III).

1843: Prince Louis Napoleon, heavily indebted, sells the property of Arenenberg and seeks to sell the reliquary. The drawing of the reliquary signed by Prince Louis Napoleon could date from this period.

1844: An engraving of the reliquary appears in the newspaper *L'Illustration*.

1855: A reliquary box is made for the talisman by Parisian goldsmith Froment-Meurice.

1866: Charles Clément, deputy curator at the Louvre, appraises the reliquary accompanied by an engraving by the German historian and archaeologist Ernst Aus'm Weerth.

1919: Napoleon III's widow, Empress Eugénie, moved by the fire of the Cathedral of Reims, donates the talisman to the Archbishop of Reims.

1960s: First expert examination is carried out by Bernard Gomond.

1962: The talisman is classified as a historical monument and deposited in the treasury of the Palace of Tau.

Characterization of the Center Sapphire. The basic polishing and fashioning of the large center sapphire strongly suggests that it is contemporaneous with the reliquary. It could, however, be a recycled stone from an antique jewel. The presence of unaltered inclusions indicates that no heat treatment was applied to improve its clarity and color. Its shape is slightly trapezoidal, broader at its base. Its dimensions are 41 mm long × 25–29 mm wide. Its approximate depth can be estimated as 16 mm, since the total thickness of the sapphire and glass cabochon is 35 mm, and we can assume that the space between the two stones is less than 1.5 mm keeping the wooden cross relic fixed in place. Based on these measurements, we estimate the weight of the center sapphire as approximately 190 ct (38 grams). To our knowledge, the center sapphire of the Talisman of Charlemagne is the largest sapphire used in European jewelry during the Early to High Medieval period. For comparison, the historic Grand Sapphire of Louis XIV weighs 135 ct or 27 grams (Farges et al., 2015).

Possible Substitution with the Blue Glass Cabochon. As indicated earlier, various descriptions of the main center stones have been recorded. The 1844 newspaper article in *L'Illustration* mentions two sapphires: "This talisman is a gold reliquary, round, encrusted on the surface with precious stones and whose middle is composed of two superimposed raw sapphires which contain a piece of the True Cross." Charles Clément, deputy curator at the Louvre, also notes the presence of two sapphires, one "square cabochon. Big coarse cabochon weak stone of imperfect color" and one "oval cabochon. Big sapphire perfect in water and size, pale blue…" (Aus'm Weerth, 1866). Other descriptions, which are probably much less reliable, indicate gems other than sapphire. Lucien Daudet in *L'inconnue* (1922) describes an aquamarine: "The relic known as the Talisman of Charlemagne is a piece of the True Cross enclosed in a great aquamarine." Alexandre Dumas peré mentions an emerald as the major stone of the talisman in his 1833 book *Impressions de voyage en Suisse*, as does Augustus C. Hamlin (1884).

The substitution of a large gem by an oval glass cabochon is attested to by Taralon (1966), based on his description of the gold setting, his sketchings, and his own photographs taken during the talisman restoration and compared to 1866 photographs. The main argument is that the glass cabochon does not match the shape of the bezel setting, which was similar to the shape on the back (see figure 4), and therefore was roughly forced into the talisman (Taralon, 1966; Scordia, 2012). Furthermore, the perfect oval shape and polishing of the glass cabochon as well as its composition (Co-doped lead glass with a high amount of potassium flux) are similar to that of blue potassium-rich smalt glass developed during the sixteenth century and generally used from the eighteenth century (Boon et al., 2001). Based on these factors, we can hypothesize that the glass cabochon was created during the eighteenth or nineteenth century.

Several hypotheses of substitution are therefore possible. Taralon (1966) mentions a possible incident when the relics were relocated from Aachen to Paderborn during the French Revolution. However, comparison between the present talisman with the 1834 portrait of Queen Hortense (figure 2), the circa 1843 drawing (figure 3), and the 1866 engravings (figure 4) indicates that the oval cabochon was already in place around 1843 and thus before 1866, with its present-day dimensions and appearance. Therefore, we believe that the 1844 indication of two superimposed raw sapphires ("Talisman de Charlemagne," 1844; Aus'm Weerth, 1866) is a mistake due to gemological confusion by nonspecialists who described the talisman from engravings and were seeking a sensational story. The substitution of the front center gemstone (which could have been another large sapphire) by the glass cabochon, therefore, probably occurred at the end of the eighteenth century and certainly before 1843.

CONCLUSIONS

This study combined gemological analysis carried out at the Palace of Tau in Reims with thorough historical research in order to unravel mysteries surrounding the Talisman of Charlemagne. Alexandre Dumas's romantic description of the talisman in 1833 contributed to its mystery and notoriety.

The first engravings of the reliquary did not appear until the seventeenth century. However, its typical medieval goldsmithery strongly suggests a dating at least as early as the late ninth century. At the time it was part of the treasury of Aachen Cathedral and was said to contain hair from the Virgin Mary. The replacement of the hair with splinters allegedly from the True Cross probably occurred at the beginning of the nineteenth century and was very likely contemporaneous with the setting of the glass cabochon. Only then did it become known as the Talisman of Charlemagne. It then passed through the hands of Napoleon I; Josephine de Beauharnais and her daughter, Hortense de Beauharnais; and Napoleon III and his wife Empress Eugénie. The empress donated it to

the Archbishop of Reims, where it became a permanent exhibit at the Palace of Tau Museum in Reims.

Gemological examination by the present authors has made it possible to propose the geographic origin of the colored stones. Most of the garnets appear to come from southern India or from Ceylon, except one garnet of presumably Bohemian origin. The large blue-gray sapphire in the center is assumed, based on its inclusions and spectral features, to originate from Ceylon. The emeralds probably originate from Djebel Zabara, Egypt, except for one that is presumably from the Habachtal region of Austria. With this interpretation of our data, we suggest that emeralds from Egypt have entered the trade along ancient trade routes since at least the Middle Age (i.e., prior middle to late ninth century, when the Talisman of Charlemagne was made), if not even earlier. The substitution of the large gemstone in the front by a glass cabochon probably would have occurred at the end of the eighteenth century and certainly before 1843. The center sapphire's weight is estimated at approximately 190 ct (38 grams), which represents a substantial portion of the reliquary's total weight of 163 grams. This sapphire, having undergone no treatments such as heating, is to our knowledge one of the largest used in historical jewelry before the seventeenth century.

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