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THE FRENCH BLUE AND THE HOPE: NEW DATA FROM THE DISCOVERY OF A HISTORICAL LEAD CAST

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A lead cast of the French Blue diamond, a mythic item in the French Crown Jewels, was recently found in the mineral collection of the Muséum National d'Histoire Naturelle (MNHN) in Paris. The details of this diamond—stolen in 1792 during the French Revolution—have up to now been known only from a drawing of an insignia of the Golden Fleece belonging to King Louis XV that was published in 1889 and, more recently, from an unpublished rendering dated as early as 1749. Computer modeling of the French Blue from a laser scan of the lead cast revealed details of the cut that could not be inferred from these drawings. Models of both the lead cast and the Hope diamond confirm that the latter could have been recut from the French Blue. The additional discovery of the catalog entry associated with the lead cast at the MNHN suggests that Henry Philip Hope may have owned the French Blue diamond after its 1792 theft and before it was recut.

In the course of his several visits to India during the mid-1600s, famed French gem dealer and adventurer Jean-Baptiste Tavernier (1605–1689) obtained many exceptional diamonds (Tavernier, 1676; Morel, 1988). Among these was a large blue stone weighing 112 3/16 old carats (115.16 modern carats; figure 1), later called the *Tavernier Blue* by Anglo-American scholars (Balfour, 2000; Kurin, 2006), though the diamond went unnamed at the time. Based on Tavernier's writings, it has been speculated that the diamond came from the Kollur mine near Golconda. It was cut to preserve weight at the expense of symmetry and brilliance, which was a typical practice in ancient India (Morel, 1986; 1988). In 1668, Tavernier sold the diamond to France's King Louis XIV (1638–1715) for the bargain price of 220,000 livres (Bapst, 1889). This is roughly equivalent to $5 million today, and the stone was probably worth twice that: Tavernier gave his king a very good deal. In 1671, Louis ordered the diamond recut to improve its brilliance, a responsibility that fell to Jean Pitau (1634–1676), the court jeweler (Bapst, 1889). In 1673, Pitau delivered a shield-shaped stone weighing around 69 ± 0.03 ct (Morel, 1988; again, see figure 1). Jean-Baptiste Colbert, King Louis's minister of finance, dubbed the stone the *Diamant Bleu de la Couronne* (Blue Diamond of the Crown). As with *Tavernier Blue*, *French Blue* is a modern anglicism; however, this name will be used in this article for ease of understanding.

In 1749, Louis XV (1710–1774) asked Paris jeweler Pierre-André Jacquemin (1720–1773) to mount the stone in a ceremonial insignia of the Order of the Golden Fleece (Morel, 2001). Jacquemin produced two color renderings (Farges et al., 2008). The first (believed to be the final version; figure 2) shows the French Blue and Bazu diamonds, as well as the

See end of article for About the Authors and Acknowledgments.
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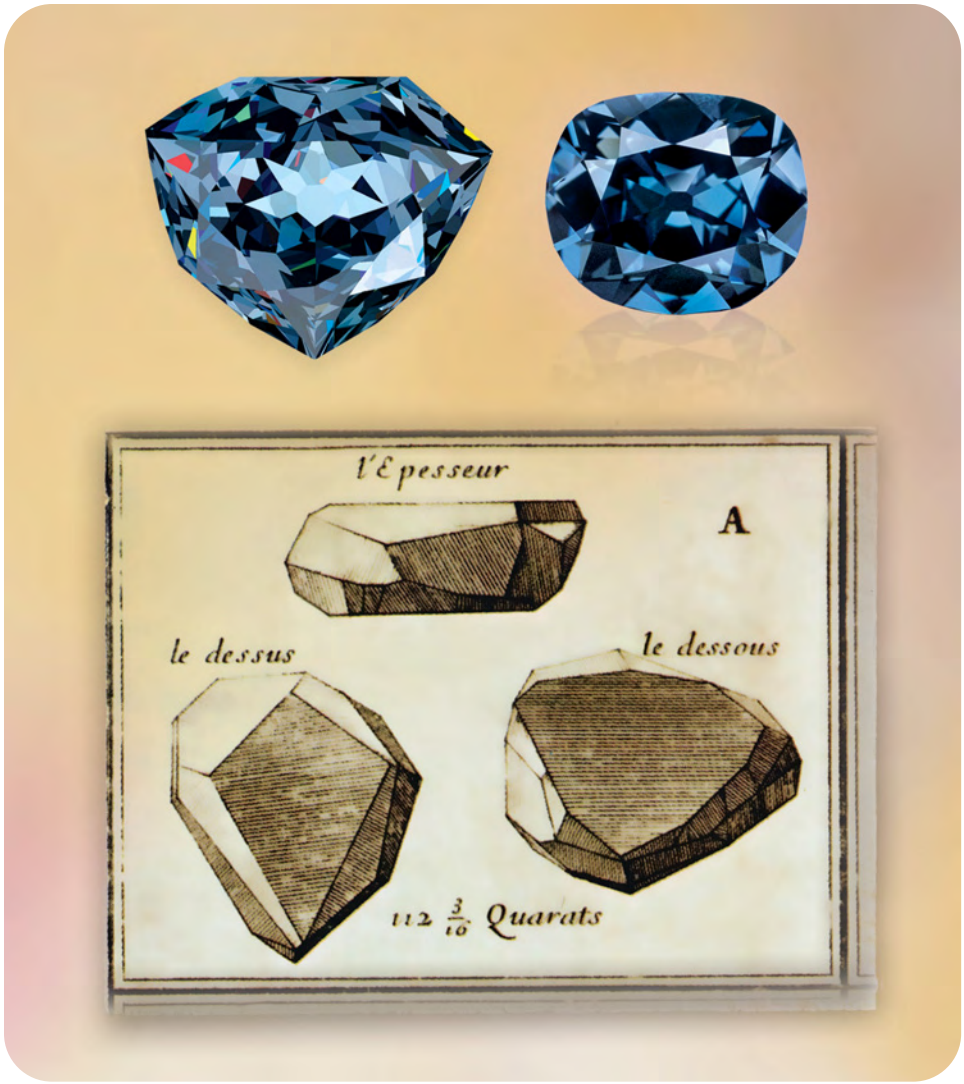


Figure 1. The Tavernier Blue diamond (bottom; shown here in a drawing from Tavernier, 1676) was an ~115 ct flat slab cut primarily to conserve weight. Louis XIV ordered it recut in 1671. The resulting ~69 ct stone came to be known as the Blue Diamond of the Crown *or the* French Blue *(computer rendering, top left), which is believed to have been recut later into the 45.5 ct Hope diamond (top right). This computer model of the French Blue was created from a lead cast recently discovered in the Muséum National d'Histoire Naturelle in Paris. Photo of the Hope courtesy of the Smithsonian Institution.*

107 ct *Côte de Bretagne* spinel (originally thought to be a ruby), which is carved in the shape of a dragon. A second version (Farges et al., 2008, p. 17) bears two large table-cut blue sapphires (six- and eight-sided, respectively); it does not appear that production of this version went any further than a rendering. The finished insignia was a masterpiece of Rococo jewelry, known as the *Toison d'Or de la Parure de Couleur* or "Golden Fleece of the Colored Adornment" (Bion et al., 1791). At some unknown time after the French Blue was mounted, Jacquemin (or another crown jeweler) created a lead cast from the insignia, which was later recovered by heirs of the Bapst family, who also served as French crown jewelers (Bapst, 1889). Germain Bapst later wrote that it was a tradition in his family to create lead copies of the crown jewels for documentary purposes. The whereabouts of this lead cast are unfortunately not known; the drawing reproduced in Bapst's book (figure 3) is the primary record. A lead cast of the French Blue itself was also prepared at some point (possibly as late as 1812, see below), though the party responsible—whether Pitau, Jacquemin, or another jeweler—is also unknown.

In September 1792, during a wave of revolutionary rioting that swept across Paris, a gang of thieves broke into the Royal Storehouse, the *Garde-Meuble*, and stole most of the French Crown Jewels (including many loose gemstones and pearls) over the course of five nights (see, e.g., Bapst, 1889; Morel, 1988). Bapst suggested that one of the thieves, Cadet Guillot Lordonner, left Paris with the Golden Fleece of the Colored Adornment on the first day of the theft and unmounted the French Blue and the Côte de Bretagne spinel from the setting at some point during his journey between Nantes and le Havre. He made his way to London, where he tried to sell the Côte de Bretagne to exiled French monarchists.

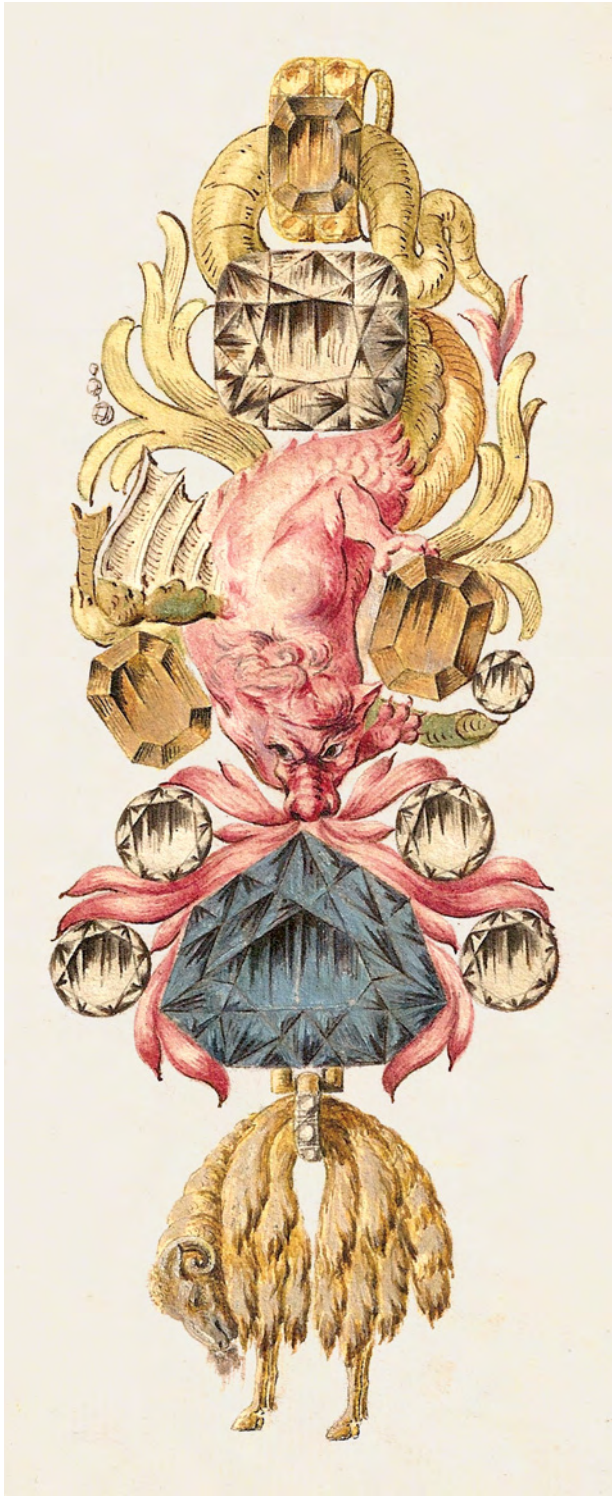


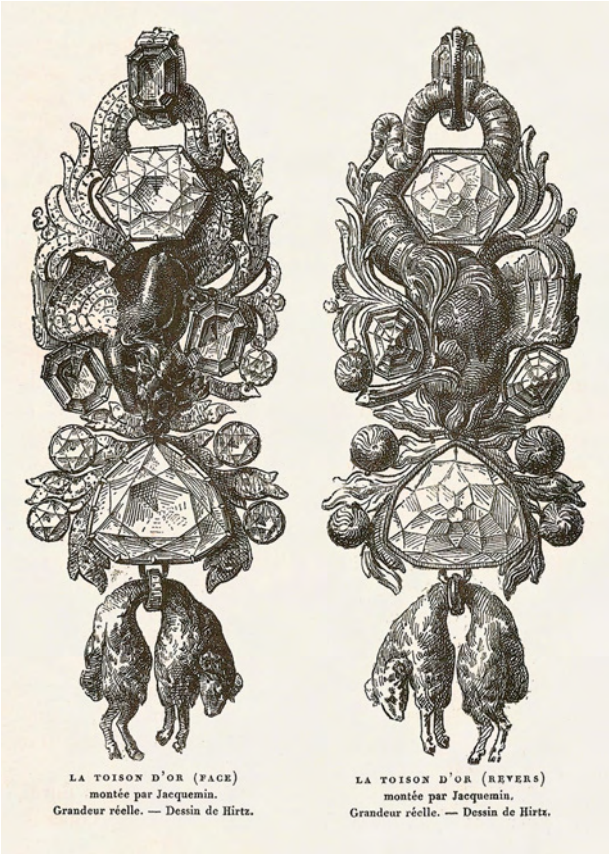
Figure 2. This color rendering of Louis XV's Order of the Golden Fleece by jeweler Pierre-André Jacquemin (after 1749) is the only surviving contemporaneous drawing of the insignia, and the only known color drawing of the French Blue diamond. Note the presence of a large rounded square brilliant (the Bazu diamond, according to Morel, 1988) above the red spinel dragon.

(This rapid exit from the country would have been necessary because Guillot had taken perhaps the two most recognizable colored gems in the entire collection.) Although most of the large diamonds were later recovered, none of the jewels, such as the Golden Fleece insignia, ever reappeared. Only the Côte de Bretagne spinel surfaced in London in 1797 and was reintegrated into the French Crown Jewels in 1824; it is now housed at the Louvre Museum.

In 1804, Napoleon's government issued a law providing for a 20-year statute of limitations on crimes committed during the revolution (Winters and White, 1991). This meant that criminal liability for the theft would apparently end in 1812 (though Morel, 2001, suggested otherwise, arguing that this law did not apply to the crown jewels).

The French Blue was never seen again in its

Figure 3. These drawings by Lucien Hirtz (from Bapst, 1889, pp. 268–269) depict a lead cast of the Golden Fleece that was made at some unknown time after the jewel was created. Compare it to the Jacquemin rendering; note especially the different diamond mounted at the top.



original form, but another large blue diamond did appear—exactly 20 years and two days after the theft. In 1812, London jeweler John Francillon (1744–1816) described a 45.5 ct "deep blue" diamond "without specks or flaws" that he had seen (Francillon, 1812; figure 4). The owner of the diamond was not named; Francillon simply reported that he examined it "by leave of Mr. Daniel Eliason" (1753–1824), who was a London diamond merchant at the time (Patch, 1976; Balfour, 2000). Why Eliason revealed this stone—the future Hope diamond—to Francillon, and whether he owned it himself or was acting at the behest of another, is not known.

The first documented (Hertz, 1839) owner of this stone was Henry Philip Hope (1774–1839), from whom it obtained its current name. However, no clear or reliable evidence exists to document how and when Hope acquired his blue diamond; he was known to maintain secrecy about his collection, presumably for tax reasons (Rivington and Rivington, 1845). Eventually, the blue diamond passed through the Hope family to America by way of French jeweler Cartier (Ross, 2005; Kurin, 2006). In 1958, New York jeweler Harry Winston donated the Hope diamond to the Smithsonian Institution in Washington, DC (Patch, 1976; Balfour, 2000).

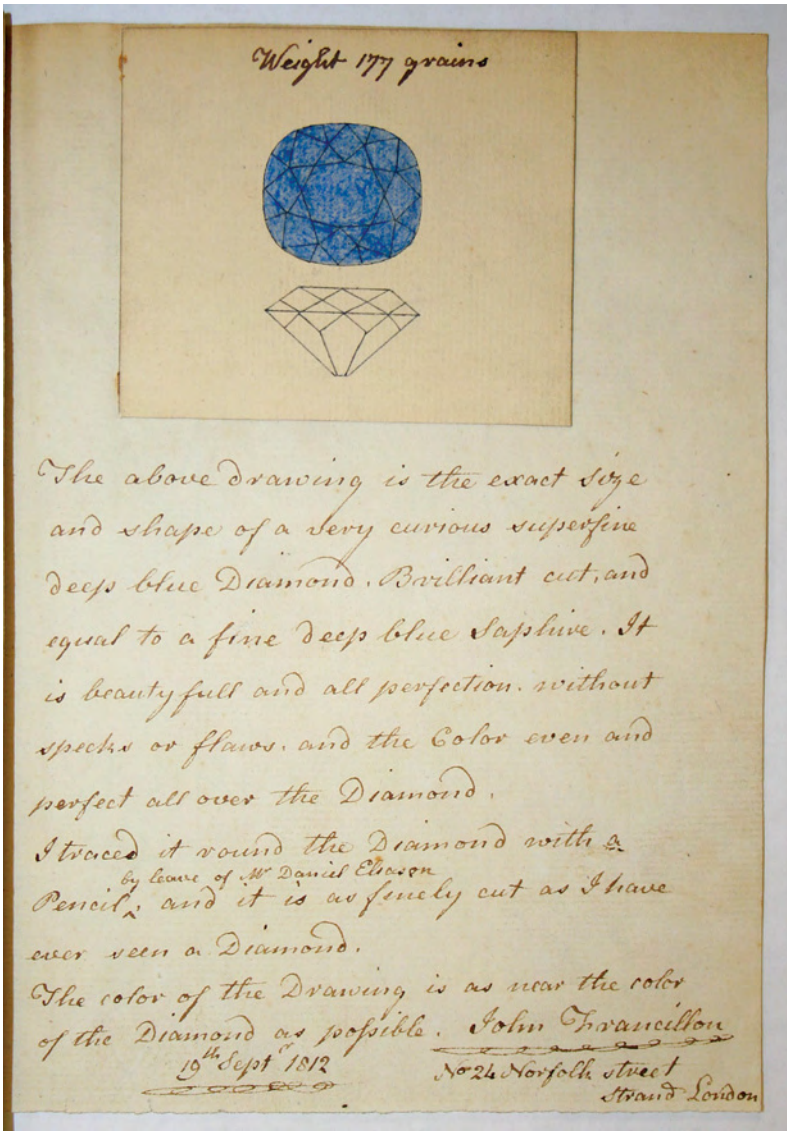


Figure 4. This 1812 sketch and description by London jeweler John Francillon is the earliest public record of what would become known as the Hope diamond. Courtesy of the U.S. Geological Survey Library.

PREVIOUS ATTEMPTS TO RECONSTRUCT THE FRENCH BLUE

In his 1889 book on the French Crown Jewels, Bapst claimed that Hirtz's drawing of the lead cast of Louis XV's Golden Fleece (again, see figure 3) was at the correct (1:1) scale. However, Morel (1988) determined that Hirtz's drawing of the French Blue, if indeed to scale, was too narrow to accommodate the Hope (figure 5, left). In attempting to prove his thesis that the Hope was recut from the French Blue, Morel expanded Hirtz's drawing to the dimensions published a century earlier by Brisson (1787). Morel's converted metric dimensions were 31.00 × 24.81 × 12.78 mm. To assess the validity of this approach, Morel compared the dimensions of the Regent diamond given by Brisson to a more modern measurement reported in 1884 by Jacob (described in Morel, 1988). He found the exact same values—down to a hundredth of a millimeter—for the Regent: 31.58 × 29.89 × 20.86 mm.

Unfortunately, in checking Morel's work ourselves, we found that his dimensions for the French Blue were likely underestimated because Jacob had overestimated those of the Regent. The Louvre Museum, where the Regent is now housed, reports the measurements to be 30.5 × 28.9 × 20.3 mm ("Diamond, known as the 'Regent,'" 2009). Thus, Brisson's measurements are not as accurate as Morel estimated (± 0.05 mm on average) but rather ± 0.9 mm, a far more plausible range given the limitations of 18th-century instruments. Assuming similar discrepancies with Brisson's measurements for the French Blue, we calculated a revised estimate for that stone of 29.99 × 23.96 × 12.11 mm. These differences confirm that we cannot know the dimensions of the French Blue below the millimeter level from these records alone.

In addition to these problems, even after Morel increased the calculated length of the French Blue diamond from 28.0 to 31.0 mm, two small but significant inconsistencies remained between the known dimensions of the Hope and those of his hypothetical French Blue. Nevertheless, his final model for the French Blue fully encloses the Hope, so we believe Morel distorted Hirtz's drawing for this purpose. In the end, Morel's version of the French Blue diamond more closely resembled a regular heptagon (figure 5, center) than the truncated triangle in Bapst (1889).

Based on Morel's information, researchers at the Smithsonian Institution coordinated a reconstruction of the Tavernier Blue and French Blue diamonds and reexamined their relationship with the Hope. As part of that effort, Attaway (2005) and Sucher (2005) created two similar three-dimensional (3D) computer models of the French Blue (e.g., figure 5, right), as well as replicas in cubic zirconia and plastic. By comparing those models to a computer model of the Hope, Attaway and Sucher both confirmed what had been suspected since at least the mid-19th century (Barbot, 1858) and which was analyzed first by Morel (1988): that the Hope was cut from the stolen French Blue, leaving insufficient material for smaller diamonds.

However, as pointed out by both Morel (1988) and Kurin (2006), Hirtz's line drawings (and subsequent printings) are likely subject to error and artistic license. This can be clearly demonstrated by analyzing the Côte de Bretagne spinel. Comparing a contemporary high-resolution photo of the spinel to the drawings (figure 6, left and inset), Hirtz's distortions of the Côte de Bretagne can be seen to be significant—on the millimeter level, which is relatively large given the size of the carving (~45 × 17.6 mm; these dimensions were estimated from a comparison with the Regent because the actual artifact was not directly available to us; thus, scaling errors in Hirtz's drawing cannot be traced precisely).

In addition, because Hirtz depicted both the front and back of the ornament, the drawings can be checked for consistency by overlaying a mirror image of the back side onto the front. Although this exercise showed remarkably few inconsistencies (figure 6, right), some small but significant differences do exist (indicated by arrows in figure 6). This again confirms that any reconstructions from those drawings cannot be accurate below about the millimeter level.

Last, and perhaps most importantly, the Hirtz drawings show only the crown and pavilion of the French Blue, with no side views. Thus, all studies based on these drawings have had to estimate the total depth and the girdle details using the French Blue's reported weight (Attaway, 2005; Sucher, 2005). This has a critical influence on the appearance of the gem, as the precise angles between facets cannot be determined from the Hirtz drawings.

THE LEAD CAST OF THE FRENCH BLUE

Discovery. A recent (2007) update of the inventory of the mineral and gem collection of the Muséum national d'Histoire naturelle (MNHN) in Paris turned up the lead cast of a large (30.38 × 25.48 × 12.88 mm) shield-shaped diamond (figure 7) with dimensions similar to those previously reported for the French Blue (Farges et al., 2008; see table 1). This cast, catalogued in 1850 (its acquisition year is not known), is also notable because of its entry in

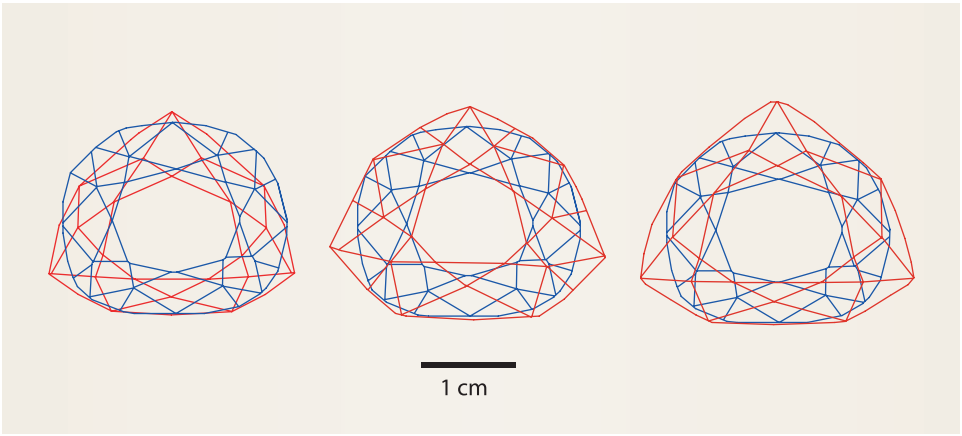


Figure 5. Various line drawings of the French Blue (in red) are compared to a drawing of the Hope diamond (in blue, courtesy of the Smithsonian Institution): left=based on the original Hirtz drawing (Bapst, 1889); center=based on the model calculated by Morel (1986) after stretching and distorting the drawing by Hirtz; and right=from the computer model by Sucher (2005), after only an iterative stretch of the drawing by Hirtz.

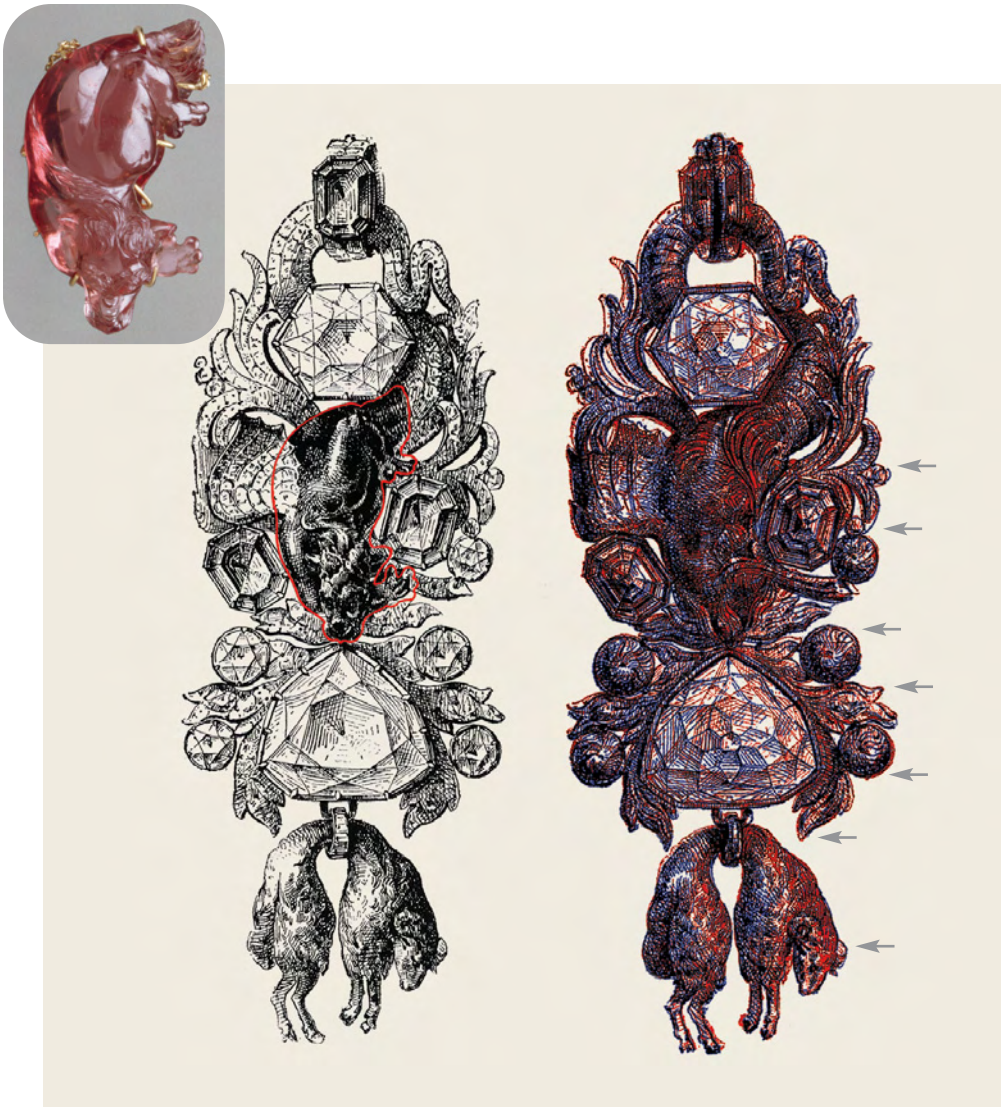


Figure 6. At left, the 107 ct Côte de Bretagne spinel in the Hirtz drawing, when compared to the actual shape of the dragon (inset and red contour line, which has been rescaled for the best fit with the drawing), shows a number of errors and distortions. At right, when the front and the horizontally flipped back of the Hirtz drawings are overlaid, additional inconsistencies (gray arrows) between the two drawings become apparent. The inset shows the actual spinel (~45 × 17.6 mm), which is currently housed in the Louvre; photo © Réunion des Musées Nationaux/Art Resource, New York.

the MNHN catalogue (inventory no. 50.165; figure 8), which reads (in French) "Mr. Achard, Lapidary—Lead model of a diamond belonging to the Crown of Portugal—cut following the shape of a diamond." The subsequent entry (50.166), also catalogued in 1850, reads, "ibid, ibid [i.e., also Mr. Achard, Lapidary]—Model of a diamond, remarkable for its clarity—belonging to *Mr. Hoppe of London*" (emphasis added). The piece associated with this second entry is another lead cast, having the shape of a table-cut diamond, also known as a mirror (Morel, 1988). The mirror cut typically resembles half of a diamond octahedron (Tillander, 1996). The cast labeled 50.166 is 18 × 17 × 11 mm, which puts the approximate weight of the original diamond at 29.3 ct. Items 50.165 and 50.166 were donated to the MNHN at the same time by the same person, "Achard, lapidarist," though they could have been obtained earlier, as they are listed among minerals donated by Alexandre Wattemarre (1796–1864), a practice that he started in 1843, and those in the collection of MNHN mineralogy curator René-Just Haüy (1743–1822), which was acquired in 1848. The catalogue for 1850 lists numerous samples dating from the French Revolution or the First Empire; these were not catalogued for decades afterward because of the lack of space and a lack of funding during the post-Napoleonic period.

The 50.165 lead cast is, as evident in figure 7, a shield-shaped stone, certainly not a cut that follows "the shape of a diamond." Further, there have been no reports of a shield-shaped diamond of about 68–69 ct (the approximate weight of the diamond from which it was cast) in the Portuguese Crown Jewels (Twining, 1960; Morel, 2001).

The remark in the 50.166 catalogue entry about the clarity of the diamond obviously cannot be verified by comparing it to the cast. However, the 50.166 cast *does* resemble half of a natural diamond crystal. Further, the mirror cut, in existence since

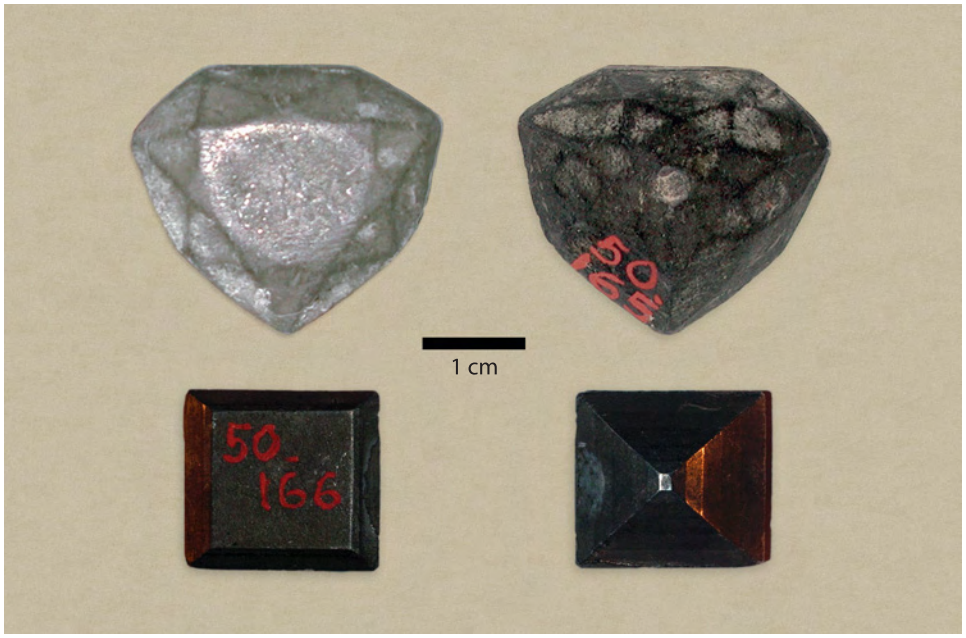


Figure 7. These two lead casts—both table-up and table-down views are shown here—were catalogued in 1850 by the MNHN, Paris: MNHN 50.165 (top) and MNHN 50.166 (bottom). Item 50.165 is a cast of the French Blue. Photos by F. Farges, ©MNHN.

the late 1500s, was found in many crown jewel collections throughout Europe during the Renaissance period. In addition, the 50.166 cast is stored inside a box with a "N°1" written on the interior, although it is listed second in the catalogue.

The discrepancies between the entries and their corresponding casts can be rectified if we assume the numbers were inadvertently transposed when the casts were logged in or that the casts were switched at some point, probably before the donation was received by Armand Dufrénoy (1792–1857), who catalogued them in 1850. (Dufrénoy had been tasked with singlehandedly cataloging tens of thousands of specimens because of the backlog noted above.) Thus, it is logical to conclude that the 50.166 entry, attributing the original to a "Mr. Hoppe of London," actually corresponds to the 50.165 cast resembling the French Blue. The comment about the original's remarkable clarity would certainly fit a Golconda diamond such as the French Blue (Brisson, 1787), as well as what is known about the Hope from both Francillon's initial report and more modern examinations (e.g., Crowningshield, 1989, which reports a GIA clarity grade of VS1).

TABLE 1. Dimensions for the French Blue from historical references, compared to those of the lead cast MNHN 50.165.

Reference	Length	Width	Thickness	Weight
Bion et al. (1791)	—	—	—	268 1/8 *grains*, *poids de marc*[a] (68.97 ct)
Brisson (1787)	13 3/4 *lignes*[b]	11 *lignes*	52/3 *lignes*	260 *grains*, *poids de marc*[a]
Brisson (1787), converted by Morel (1988)	31.00 mm	24.81 mm	12.78 mm	69.03 ct (69.05 ct)[c]
Brisson (1787), converted based on a modern set of dimensions for the Regent diamond[d]	29.99 mm	23.96 mm	12.11 mm	—
Hirtz (Bapst, 1889), measured from drawing at 1:1 scale	28 mm	24 mm	—	—
Average error		± 0.9 mm		± 0.06 ct
Lead cast MNHN 50.165	30.38 mm	25.48 mm	12.88 mm	68.3 ct

[a] *1* ligne = *2.2558 mm (Morel, 1988).*
[b] *1* grain, poids de marc ≈ *0.0531147 g ≈ 3.765 ct (Lionet, 1820).*
[c] *Morel underestimated the actual weight of Brisson by 0.02 ct; the accurate value is 69.05 ct.*
[d] *As provided by the Louvre Museum (30.5 × 28.9 × 20.3 mm).*

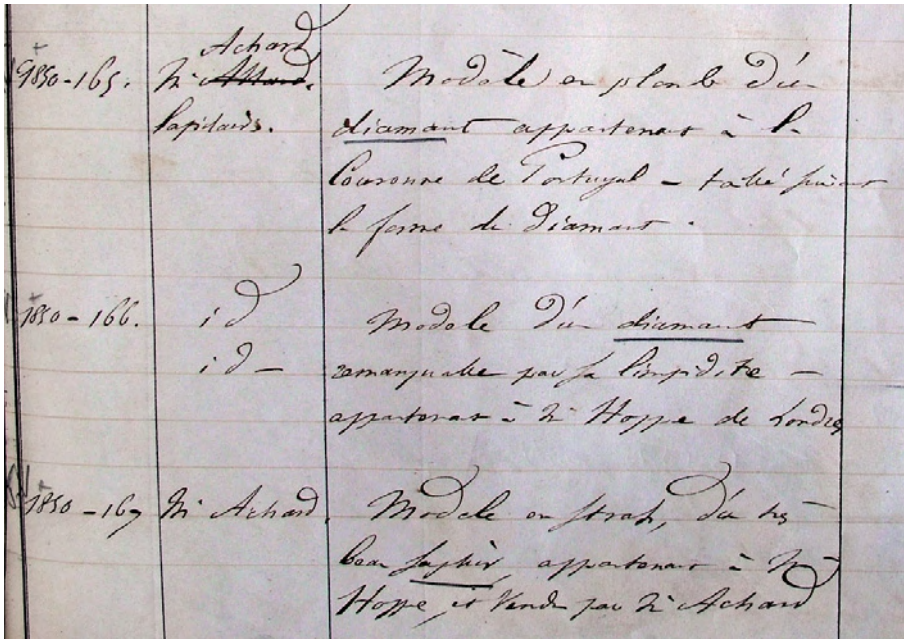


*Figure 8. The entries in the 1850 catalogue showing the numbers and descriptions for MNHN 50.165 and 50.166 do not match the items. Entry 50.165 reads, "*M. Achard, Lapidaire—Modèle en plomb d'un diamant appartenant à la Couronne de Portugal—taillé suivant la forme du diamant.*" ("Mr. Achard, Lapidary–Lead model of a diamond belonging to the Crown of Portugal—cut following the shape of a diamond."). Entry 50.166 reads, "*ibid, ibid—Modèle d'un diamant remarquable pour sa limpidité—appartenant à M. Hoppe de Londres*" ("ibid, ibid—Model of a diamond, remarkable for its clarity—belonging to Mr. Hoppe of London"). The labels were apparently switched accidentally at some point.*

The Donors: The Achard Family of Parisian Jewelers. Little information could be found concerning the identity of the lead cast's donor. In 1817, René-Just Haüy described a certain Mr. Achard as "one of the most knowledgeable jewelers of this city [Paris] for everything that deals with the objects [gems] of his business" (1817, p. 235). Babinet (1857, pp. 14–15 and 57) wrote that Charles Achard (likely the previous Achard's son, given the date) was known to be "involved more than any other in France concerning the business of colored gemstones." This author also mentions Charles Achard's father, though not by name. A third Achard, Edouard (most likely the grandson of the senior Achard), was the director of the Parisian Chamber of Commerce for the trading of gemstones, and was appointed by the Third Republic to supervise the disastrous sale of what remained of the French Crown Jewels in 1887. Based on the time frame, the MNHN donor was likely Charles Achard, a contemporary of Babinet (1794–1872) and probably then a prominent Parisian lapidary. It is possible that his father was also named Charles, though we found a "David Achard joaillier [jeweler]" in some 19th-century Parisian archives, with no precise dates (birth, wedding, or death).

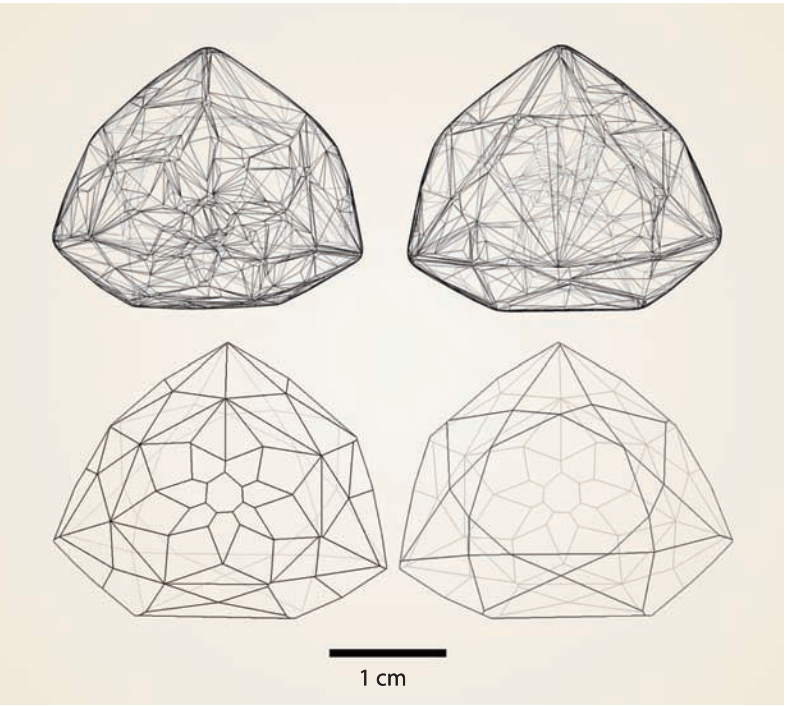
Origin of the Cast. We do not know who made the cast or how the Achards obtained it. Nor do we know its age. The patina of the lead certainly suggests that the model is quite old or has been extensively used, or both. Pitau, as the original cutter, is the most logical fabricator, in keeping with his duty as one of Louis XIV's jewelers (though it appears that few such casts were actually produced; Bapst, 1889). It is also possible that Jacquemin prepared a model to better construct his Golden Fleece for Louis XV. Neither scenario explains how the cast ended up with the Achards, who were never granted the right to work directly for the kings of France prior to the Revolution (Morel, 1988). It is known, however, that some of Jacquemin's possessions were auctioned after his death in 1774; these could have included the renderings of the insignia (again, see figure 2) as well as the cast.

Alternatively, the senior Achard, who would have been an apprentice during the first years of the Revolution, could have created a cast of the French Blue before its theft in 1792. As Brisson was allowed by the authorities in charge of the Royal Storehouse to measure the dimensions and density of the French Blue—which would have necessitated unmounting—in 1787, it could have been unmounted on other occasions as well. Achard could conceivably have obtained the diamond from the Royal Storehouse just for the purpose of making the cast, but this seems unlikely: Unlike Brisson, who was a famous scientist and a member of the French Academy of Sciences, the Achards did not become prominent until the Revolution or the First Empire (Haüy, 1817; Babinet, 1857) and were not known to be among the jewelers who served the aristocracy (Bapst, 1889). Thus, there is very little chance that the Achards could have borrowed the diamond from the Royal Storehouse to produce the cast during this period.

Finally, based on the label, it is possible that the cast was created while the diamond was in the possession of "Mr. Hoppe of London." This would likely mean that the cast was made just before the French Blue was recut, much as similar models were made for the rough of the Pitt diamond, cast in London before it was cut into what would become the Regent (Morel, 1988), and for the Koh-i-Noor prior to its recutting in 1851 (Sucher and Carriere, 2008). Morel (1988) proposed that John Francillon (born Jean Françillon), a French Huguenot lapidary (like the Achards) who had emigrated to London, could have been the party tasked with recutting the French Blue into the Hope; thus, he might have produced a cast of the French Blue before he began his work.

Whatever its origin, this cast allowed, for the first time, precise calculation of the shape and dimensions of the French Blue, including the missing thickness information (girdle, pavilion and crown) as well as the angles for each facet. To take advantage of this unique opportunity, we used laser scanning and computer modeling to recreate an exact model of the diamond, based on the lead cast and the Jacquemin drawing that shows the diamond in color. We also used this simulation to reconstruct Louis XV's colored Golden Fleece insignia based on the information available. Special care was given to propose a reconstruction that was plausible for a jeweler, as the drawings of Jacquemin and Hirtz omit important details, such as the hundreds of smaller diamonds the jewel was known to contain (specifics of this reconstruction are discussed in Farges et al., 2008). Last, we examined the implications of this new information for the history of the Hope and the French Blue.

Figure 9. The original laser-scan data from the lead cast of the French Blue (top), when cleaned of scanning artifacts and imported into DiamCalc, produced the facet diagram at the bottom (table-down, left; table-up, right).



MODELING THE FRENCH BLUE FROM THE LEAD CAST

Methodology. The cast was laser-scanned by Matrix Diamond Technology in Antwerp, Belgium, using an Octonus Helium 1:4 scanner (Sucher and Carriere, 2008). The accuracy of the 3D GemCad model is better than 40 µm (analog) or 28 µm (digital). The scan data generated a solid consisting of 2,792 planar surfaces (figure 9, top). The resulting 3D image was then cleaned of scanning artifacts (figure 9, bottom) by importing the GemCad model into Diamond Calculator 3.0 software (DiamCalc; Sucher and Carriere, 2008).

DiamCalc can also create a 3D model that adjusts reflection and refraction based on a programmable refractive index. We employed this method to get an indication of how well diamond cutting in 1670 was guided by the laws of optics, and to compare the brilliance of the lead cast–derived model with that created by Sucher (2005) based on Hirtz. By default, DiamCalc produces simulations of colorless diamonds, so to simulate the French Blue we used a color profile of the Hope diamond provided by Dr. Jeffrey Post of the Smithsonian.

Matching the Lead Cast to the French Blue. The shape and facet patterns of the cast as derived from the laser scan (again, see figure 9) were somewhat different from those recorded by Jacquemin (figures 2 and 10a) but were strikingly close to those reported by Hirtz (Bapst, 1889), especially the crown facet patterns (figures 3 and 10b). They deviated significantly from Morel (1986; figure 10c) but less so from Sucher (2005; figure 10e). The pavilion facet pattern in Hirtz was similar to that of the replica, but with a few notable differences: The size, shape, and placement of the culet matched, as did the first row of facets; however, the cast's pattern is more complex than the drawing in its upper pavilion facets (figure 11). Still, the patterns in Hirtz and in the cast are

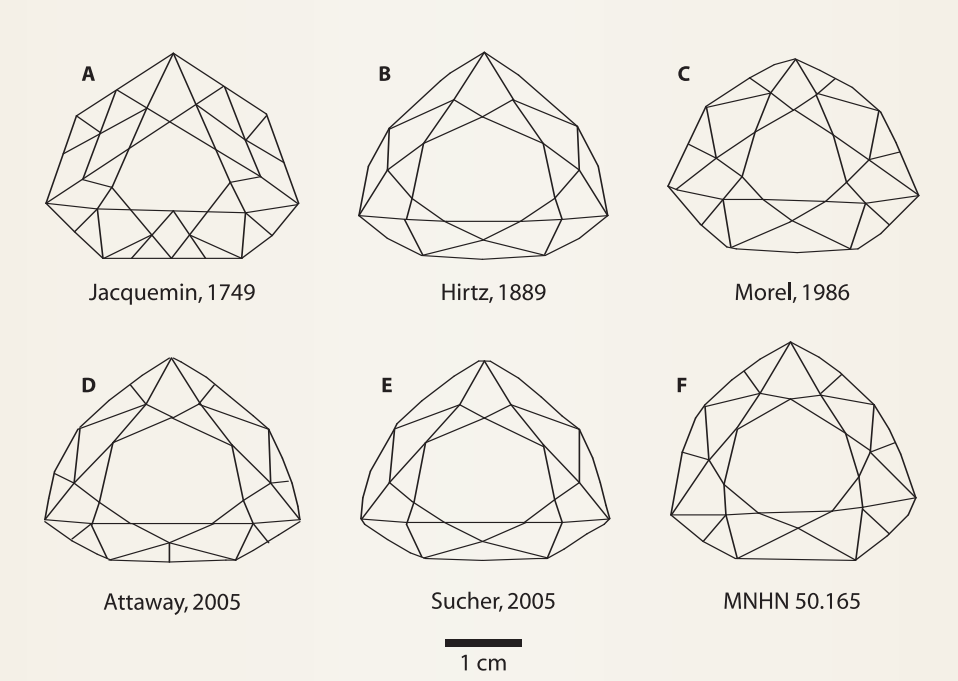


Figure 10. Shown here are diagrams of the crown facet patterns of the French Blue as derived from various sources: (a) Jacquemin's 1749 drawing; (b) Hirtz's drawing (Bapst, 1889); (c) Morel (1986); (d) Attaway (2005); (e) Sucher (2005); and (f) the MNHN 50.165 lead cast (this study). All drawings are scaled except for (a), for which no scale was provided (so it is scaled to Brisson, 1787).

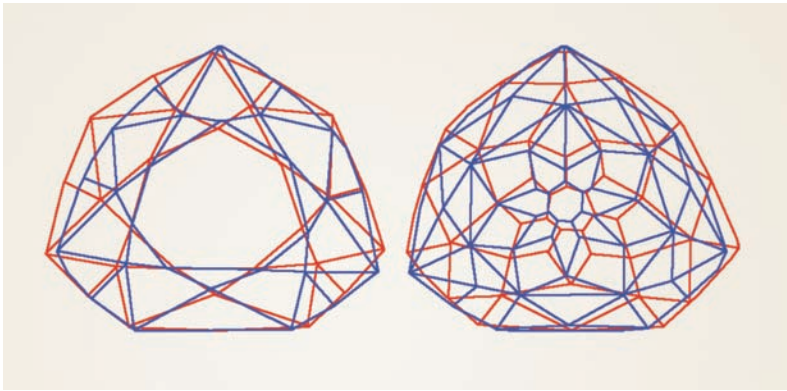
sufficiently consistent with each other, and with the diamond-cutting style used in the 17th century (Tillander, 1996), that we feel confident in identifying the cast as being taken from the French Blue.

Weight. A variety of weights have been reported for the French Blue, though they are consistent for the most part. A 1791 inventory of the crown jewels (Bion et al.) gave the weight as "268⅛ gr" (*gr = grains, poids de marc*); the same weight is also given on Jacquemin's 1749 drawing (again, see figure 2). This value is equal to that given in a 1691 inventory ("67 ks ⅛"; ks = old carat); both values convert to 68.97 modern carats (Morel, 1988). Similarly, Brisson (1787) reported a weight of 260 *grains, poids de marc*, which Morel (1988) calculated to be equal to 69.03 ct (erroneously; the actual value is 69.05 ct). From this, Morel (1988) estimated the average weight to be 69.00 ± 0.03 ct. Brisson (1787) reported his weight error to be 1/64 of a grain (±0.004 ct), but his values have since been shown to be closer to ± ¼ grain (±0.06 ct, which seems reasonable for 1787).

Using a Tescan scanning electron microscope operating at 15 kV under low vacuum conditions, we performed chemical analysis of the cast. The results showed a composition of 97 wt.% lead, 2 wt.% tin, and traces of iron and zinc. Based on the density of this measured composition (11.2 ± 0.1 g/cm^3) and the density of 3.5254 g/cm^3 for the French Blue reported by Brisson (1787), we estimate that the cast is equivalent to a 68.3 ± 0.2 ct diamond (n.b.: the accepted density of diamond using modern techniques is 3.51–3.52 g/cm^3; Bari and Fritsch, 2001).

However, the weight represented by the cast in its current condition is probably not what it was originally because of the rounded edges and worn and weathered surface [partially covered by hydrocerussite, $Pb_3(CO_3)_2[OH]_2$]. Assuming the original edges of the cast were reduced by 0.5 mm each, this gives a loss of ~0.3 ct of diamond. Thus, our estimated weight for the French Blue derived from the cast, 68.3 ct, is 0.4 ct lower than the low end of Morel's (1988) range, which is only a ~0.5% variance. This is further strong evidence tying the cast to the French Blue diamond.

Figure 11. Overlaying the computer model derived from the lead cast (blue) on that derived from Hirtz (red) shows notable differences in the arrangements of the crown and pavilion facets.



Dimensions. The published dimensions and weights estimated for the French Blue are shown in table 1. The dimensions of the cast are 30.38 × 25.48 × 12.88 mm (±0.01 mm). These match those reported by Brisson (1787)—converted based on the modern set of dimensions for the Regent diamond—within ±0.9 mm on average. No sink marks (depressions from contraction of the lead) were observed on the cast, suggesting that significant lead shrinkage did not occur. Based on the linear expansion coefficient of lead (~28 × 10^{-6} mm/K), we calculated that the cast should have contracted by a maximum of 0.3 mm along the length and width, and 0.1 mm in thickness, during the cooling from its molten state (i.e., over 400°C). Such shrinkage can be reduced by the use, for instance, of warm molds, a technology well known since the end of the 17th century.

If we compensate for this lead shrinkage, the corrections to the French Blue's dimensions are still within Brisson's margin of error. However, the weight would then have to be increased by 4.5 ct, which is significant even for Brisson. Therefore, we believe that no significant shrinkage occurred during the making of the cast. If we assume the weight of the diamond to be 69.0 ct, then only a maximum of 0.1 mm shrinkage in length and width and <0.01 mm in thickness could have taken place. Therefore, we estimate that the maximum dimensions were 30.5 ± 0.1 × 25.6 ± 0.1 × 12.9 ± 0.1 mm.

Design and Shape. The cast has a thin crown (<3 mm) and a relatively thick pavilion (9.97 mm) as compared to earlier replicas, and a thin (<0.5 mm) and very even girdle. Hirtz's drawing (again, see figure 3) shows a central culet with seven culet facets around it. The culet facets are surrounded by seven kite-shaped primary main facets, with another row of seven kite-shaped secondary main facets surrounding these. Fourteen break facets define the girdle. However, the cast has a second row of main facets that are horizontally split (total 14), plus a tertiary row of 14 additional main facets. In contrast to the 14 break facets in Hirtz's drawing, there are only 13 on the cast. The drawing has a total of 36 pavilion facets; 57 are present in the cast (table 2). However, the break facets along the girdle are vertically split, with break side facets. The presence of break facets on both the crown and the pavilion (again, see figure 9) contributes to the artistic symmetry of Pitau's design.

When we compare our model to that of Attaway (2005), it is evident that the facet patterns are similar, with the extra facets on the pavilion of the cast model primarily being the result of the horizontal splitting of some facets on Attaway's model (again, see figure 11). The angular differences between the two halves of the split facets range in the vicinity of 3–5°, just enough to discern them as separate facets rather than one rounded facet. There is also one extra row of facets on our model. The crown facet patterns differ only in the configuration of the break facets: They are vertically split in Attaway's model and not split on ours.

Hirtz's model can also be analyzed and compared to the other measurements using its length-to-width ratio. Hirtz's has a ratio of 0.8571, within 1.5% of Morel's model (0.8459). Brisson's measurements (as corrected by Morel) have a ratio of 0.8003, and the lead cast has a ratio of 0.8387, between Hirtz and Brisson. This result confirms the distortions in Hirtz's drawing (Bapst, 1889), and demonstrates again the relative inaccuracy of Brisson's measurements. The overall shape of the cast (figure 10f) is much closer to that of Hirtz (figure 10b) than that of Morel (figure 10c), although the length-to-width ratio of the cast is closer to that of Morel than of Hirtz. Attaway's model shows a stone with a length-to-width ratio of 0.8589. Extended over 25 mm (approximately the length of the diamond), this results in a difference of about 0.5 mm from our model. This does not negate the validity of the earlier model, in that the Hope still fits neatly inside it. Although the depths of the two models differ, they still encompass the same volume and, hence, weight.

Computer Simulation of the French Blue. Comparison between our model and that of Sucher (2005)

TABLE 2. Summary of pavilion facet differences between Hirtz's drawing (in Bapst, 1889) and the lead cast MNHN 50.165.

Source	Culet	Culet facets	Primary main facets	Secondary main facets	Tertiary main facets	Break facets	Total
1749 drawing	1	7	7	7	0	14	36
MNHN 50.165	1	7	8	14	14	13	57

Figure 12. This computer rendering of the "French Blue" diamond, based on the color profile of the Hope diamond (courtesy of the Smithsonian), represents the model Sucher (2005) composed using Hirtz's drawing and Brisson's measurements. Compare it to the French Blue model in figure 1, derived from the lead cast, which has noticeably greater brilliance and scintillation.

using DiamCalc (figure 12) shows that the earlier model, based on published drawings and dimensions, results in a gem of lesser scintillation compared to the one derived from the lead cast (again, see figure 1). We believe the additional facets (57 vs. 36) are responsible for the superior optical effects of the lead cast model. This evidence also suggests that the lead cast is an excellent replica of the original, showing an accurate set of facets with an exact set of angles that also enhance brilliance. Thus, this lead cast was probably not copied from a distance or by memory or by an inexperienced jeweler, but rather was cast directly from the original diamond.

This simulation also demonstrates that the diamond was a masterpiece of lapidary work due to its odd number of facets (seven) around the culet (a difficult pattern to cut given the technology existing at the time) and its greatly increased scintillation and brilliance over Tavernier's original stone. Pitau's peculiar cut design became known as the *rose de Paris or à la mode des deux côtés* (Morel, 1986) and would later be used for the Hortensia diamond (Morel, 1988).

The number of facets surrounding the culet was surely not an arbitrary decision—court life at Versailles under Louis XIV was heavily steeped in ceremony and symbolism. Seventeenth-century France was a deeply Christian kingdom, and in the Bible the number seven represents spirituality and divinity (e.g., the seven days of creation and the seven sacraments in western Catholicism) and the perfection of the human form of God (e.g., the number of prophets). In addition, in Greek mythology, Apollo, the god of peace and fine arts, is commonly represented by the sun. Through its art and architecture, Versailles connected these symbolic relationships, and the palace in its entirety conveyed the message that Louis was the "Sun King," ordained with the divine right to rule (e.g., figure 13). The French Blue—with its seven-fold

Figure 13. Louis XIV was very fond of symbolism and mythology. This allegorical scene shows King Louis as Apollo, the Greek god of the sun. The seven-fold symmetry of the French Blue mimics the radial beams of the sun, as seen here illuminating the Sun King. Painting by Joseph Werner II (1637–1710?), courtesy of Réunion des Musées Nationaux/Art Resource, New York.

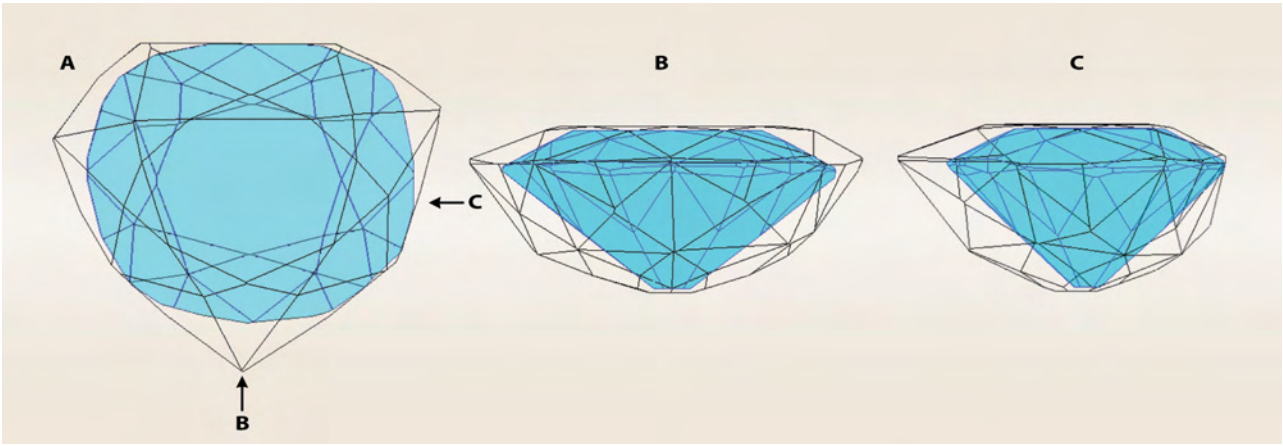


Figure 14. These views show the model of the Hope diamond (blue) inside the model of the French Blue that was derived from the lead cast (black). Note the close fit. Models B and C represent views from the respectively marked arrows on model A.

symmetry, blue color, and brilliance—was clearly intended to echo this sentiment. Pitau's design was likely intended to represent a sun with seven radial beams set in a blue sky.

The importance of this design to King Louis can be seen in the extravagant sum he paid Pitau to facet the diamond: the equivalent of half a million dollars, or about one-tenth the cost of the Tavernier Blue (Bapst, 1889)—this at a time when labor costs were not normally a meaningful element of a jewel's value. As just one example, inventories of the French Crown Jewels estimated value only by calculating the worth of the gems and did not include the metals (gold, silver, bronze, etc.) or manufacturing costs (e.g., Bion, 1791).

The simulation of the French Blue represents the rediscovery of a true masterpiece of French Baroque lapidary art. Created well before the Regent diamond (cut 1704–1706 in London), the French Blue is also one of the earliest examples of the brilliant cut, a clear departure from the classical octahedral cuts of the 17th century, such as the mirrors and Mazarins.

Comparisons with the Hope. We created a model for the Hope diamond by independently reconstructing Attaway's model using photos from Attaway (2005) and DiamCalc; there were no substantive differences between the earlier model and ours. Using GemCad, we inserted the model of the Hope diamond into our model of the French Blue (figure 14). Model resolution was 43 pixels/mm, and the Hope fit inside the French Blue with as little as 4 pixels (less than 0.1 mm) distance between the outside edges of the stones when they were rotated about all three axes. This is important, as the Attaway study reconstructed the French Blue solely from the available line drawings, without benefit of the proportions and details of the crown and pavilion provided by the lead cast. Thus, this study confirms the conclusion in the earlier works of Morel (1986) and Attaway (2005), as postulated by Barbot (1858), that the Hope could have been cut from the French Blue.

Reconstruction of the Golden Fleece. A reconstruction of the colored Golden Fleece was also painted by artist Pascal Monney of Geneva for this study. This simulation was then refined based on the 1791 inventory (Bion, 1791) to eliminate inconsistencies in some of the diamond shapes and settings, either misdrawn by Hirtz, missing in Jacquemin, or deemed irrelevant by Morel (1988) and Tillander (1996). We also added elements of the Rococo style that dominated during this period by reference to examples of other Golden Fleece insignia in museums in Lisbon, Munich, Austria, and elsewhere in Europe. Based on this, Mr. Monney's gouache of the historic piece (figure 15) is the first reconstruction that is realistic for a jeweler of the 18th century Rococo period. More detail, as well as an alternate version of the insignia, is presented in Farges et al. (2008) and will be discussed in a future paper.

IMPLICATIONS FOR THE FATE OF THE FRENCH BLUE AND THE HOPE

Ownership. The correct catalog entry for the lead cast of the French Blue states that the diamond's owner was "Mr. Hoppe of London." Who was "Mr. Hoppe"? One of Achard's most important customers was Henry Philip Hope, the first known owner of the Hope diamond. Hope was also a friend of René-Just Haüy, the mineralogy curator at the MNHN

until 1822. In his treatise on gems, Haüy (1817) thanks only two people for their readings and gem donations: Henry Philip Hope and Charles Achard. Hope had previously donated a collection of gems to Haüy, which now resides at the MNHN; this donation could well have included the lead cast, as discussed above. Further, another donation to the MNHN by the Achards, MNHN 50.167 (note the numbering immediately after the lead casts; again, see figure 8), is a glass replica of a large deep blue sapphire that the catalogue states was "sold to Mr. Hoppe of London." Given these connections, it seems logical to assume that "Hoppe" was in fact Henry Philip Hope.

In 1849, Hope's oldest nephew, Henry Thomas Hope (1808–1862), formally inherited the Hope diamond (Morel, 1988; Kurin, 2006). The trial over Hope's will was public and acrimonious (Rivington and Rivington, 1845), so by 1850 a jeweler as connected as Achard was surely aware of the diamond's existence, even assuming he had not become aware of it because of his relationship with Henry Philip Hope (who had published a catalogue of his gem collection 11 years earlier; see Hertz, 1839). Yet the lead cast is clearly that of the French Blue, not the Hope, and an experienced French jeweler like Achard could hardly have confused the two. The label suggests that one of the Achards (most likely the father) was somehow able to link Henry Philip Hope to the French Blue.

Two possibilities exist: (1) that Achard simply assumed the Hope was the recut French Blue, or (2) that the family had actual knowledge of this fact from their relationship with Henry Philip Hope. As the Hope and the French Blue were the largest blue diamonds of their time, such an assumption would have been logical enough. There is no written record of this connection prior to Barbot (1858), though this does not preclude the idea having been in circulation earlier. That said, like all gem dealers, the Achards could have had confidential information on the gems they came into contact with, and on their clients—such as Henry Philip Hope. Had Hope possessed the French Blue, the Achards would have been among the very few people who might have known about it.

However, had this information become known by other jewelers (especially the king's jewelers like Bapst), the French government or royalists hoping to please the surviving exiled heirs to the crown could have claimed or attempted to buy back the diamond, as they did with the Côte de Bretagne spinel and numerous other gems lost in the 1792 robbery. The fact that this did not occur with the French Blue suggests that it was likely recut soon after the theft. In the absence of hard evidence, such as the lead cast (which was not publicly announced until 2008), it would have been difficult to prove—especially in court—that the recut stone was once the French Blue.

Figure 15. This gouache of King Louis XV's Golden Fleece of the Colored Adornment, based on information about the piece and its gems gleaned from this study, was created in 2008 by Pascal Monney, Geneva, Switzerland (reprinted by permission of the owner).

Who Authorized the Recutting? Based on Francillon's memo, the recutting of the French Blue into the Hope could not have taken place any later than September 1812. Does the Achard label represent proof that Henry Philip Hope was involved in that recutting? Hope was certainly one of the few collectors wealthy and passionate enough to quietly purchase what would have been the most prominent stolen diamond in existence at the time. Perhaps Hope saw an opportunity to obtain the diamond, then have it recut to hide its origins.

The intriguing lack of records concerning Hope's acquisition of his blue diamond has been noted by many scholars (e.g., Balfour, 2000; Kurin, 2006). A logical assumption from Francillon's 1812 memo is that the recut diamond was then owned by London gem merchant Daniel Eliason. But other information suggests that the situation may not have been so simple.

The banking firm of Hope & Co., established in Amsterdam in 1726, was well connected with the crowns of Europe for many years (Kurin, 2006). The company provided financing to the governments of Britain, Russia, and Portugal; it also worked with the U.S. government and the French crown to provide funding for the Louisiana Purchase in 1804. And one of the company's private clients was Daniel Eliason, who used Hope & Co. to fund certain Brazilian mining activities.

Knowledge of the whereabouts of the French Blue was still a risky proposition in 1812. So why would a memo surface that year announcing the Hope's existence? Hope & Co. was acquired by Baring's in 1813—according to Balfour (2000), due to the declining state of the Hope fortune. If Henry Philip Hope owned the stone at the time, he might have commissioned Eliason to sell it, perhaps in part to raise funds to prevent a takeover.

To date, there is no hard evidence to confirm the validity of either scenario. It is interesting to note, however, that English jeweler and art expert Bram Hertz, who would later publish a catalogue of Hope's collection (Hertz, 1839), became Hope's agent for purchasing diamonds shortly after Eliason's death in 1824 (Rivington and Rivington, 1845). In that job, Eliason was possibly Hertz's predecessor.

CONCLUSION

The discovery of the lead cast of the French Blue reveals new details about the appearance of this historic diamond and allows a computer reconstruction more accurate than those of previous studies. Its quantitative reconstruction shows that the mythic diamond was a masterpiece of mid-17th century diamond cutting, a fitting symbol for Louis XIV to support his religious dominance and political authority. Our work confirms earlier studies (Morel, 1986, 1988; Attaway, 2005) that indicate the Hope diamond could have been recut from the French Blue.

In addition, the MNHN label attributing the French Blue to "Mr. Hoppe of London" suggests that Henry Philip Hope may have owned the French Blue at some point before its recutting. This is a possibility that has not been documented before this research (see also Farges et al., 2008). This new information is in agreement with the post-theft scenario proposed by Bapst (1889). However, if the label is correct, then our discovery is not fully in agreement with Kurin's (2006) "German" scenario involving the Duke of Brunswick.

Acquiring and keeping a stone of the importance and visibility of the French Blue, in any form, would have required a confluence of exceptional criteria, which would only have been possible for an individual in a position of power and great wealth. Hope's connections to the crowns of Europe would have provided an insider's view of European politics at the time, and with his personal connections to Eliason, Achard, and Haüy, Hope would have been in a position to know of the availability of any exceptional stones. Additionally, he had one of the finest personal gemstone collections in all of Europe. The statement on the MNHN label, "Mr. Hoppe of London," is not conclusive, but Henry Philip Hope certainly had the method, motive, and opportunity to acquire the French Blue and have it recut quickly to hide his possession of a stolen royal diamond.

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