Rapid Communications

A Study of the Gems in a Ciborium From Einsiedeln Abbey

Stefanos Karampelas, Marie Wörle, Katja Hunger, Hanspeter Lanz, Danilo Bersani, and Susy Gübelin

The gemstones that adorn a late-16th-century ciborium from Einsiedeln Abbey in Einsiedeln, Switzerland, were investigated by nondestructive gemological methods and EDXRF and Raman spectroscopy at the Collections Center of the Swiss National Museum. The ciborium is decorated with 17 colored stones: 10 almandine garnets, four grossular garnets, and three sapphires. Inclusions in the sapphires and a historic description of the piece suggest a Sri Lankan origin for the gems.

A group of four sacred objects belonging to the treasury of Einsiedeln Abbey, an important Benedictine monastery in Einsiedeln, Switzerland, were recently loaned to the Swiss National Museum in Affoltern am Albis, for identification of the materials used in their construction. This article presents the results of the investigation of the oldest object, a late-16th-century ciborium (a container for storing the consecrated host from a Mass; figure 1).

Einsiedeln Abbey dates from the 10th century. It is dedicated to Our Lady of the Hermits and is a destination on a major Roman Catholic pilgrimage, the Way of Saint James. The ciborium was crafted by Nikolaus Wickart, an established goldsmith, in Zug about 1592. Its construction cost 300 krones (equivalent to 975 g of gold), paid for by donations from Maximilian III of Habsburg and numerous other contributors. The main body of the ciborium depicts the 12 apostles of Jesus Christ, while the lid illustrates the passion of Christ and is where the Christogram *IHS* is engraved. On the underside of the ciborium, there are several stamps, including those of Maximilian III, Wickart, and Einsiedeln Abbey. For more information regarding the history of the ciborium, as well as a stylistic and iconographic description, see Distelberger and Lanz (2009).

The ciborium could not be removed from the Swiss National Museum laboratory for security reasons; thus, all testing took place there. The results were compared with the observations made by Father Eustache Tonassini from 1794 to 1798, during the documentation of the treasures of Einsiedeln Abbey (figure 2). Father Tonassini mentioned that all the stones and the gold had an "oriental" origin.

Materials and Methods. Only nondestructive means could be used to examine this artifact, and all the investigators wore cotton gloves to avoid causing damage. Microscopic examinations were performed on all gems using a Zeiss Stemi 2000-CS binocular microscope equipped with a fiber-optic light source and a camera. However, the object was difficult to handle under the microscope, which impacted the quality of the photos. Fluorescence reactions to standard long-wave (366 nm) and short-wave (254 nm) UV radiation were observed on all stones with an 8 watt UV lamp from System Eickhorst UV. On six stones, where the geometry of the object permitted, we performed semiquantitative chemical analy-

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sis by energy-dispersive X-ray fluorescence (EDXRF) with an Edax Eagle III XXL micro-analyzer. This instrument has a large sample chamber and is equipped with a lens for micro-measurements (spot size ~50 m). A rhodium tube was used for the analysis, under the following conditions: no filter, 20 kV, 100 µA, a livetime of 200 seconds per measurement point, and 30 points per measurement area.

Conclusive identifications were made by taking Raman spectra of all the gems and comparing them to the Gübelin Gem Lab's reference spectra as well as those in the RRUFF project (http://rruff.info) and other published references. Spectra were obtained with a Horiba Jobin Yvon (LabRam Aramis) spectrometer coupled to an Olympus metallurgical microscope. As all stones were difficult to access, we used an additional L-shaped lens (magnification 30×) to take the spectra (figure 3) and a camera for adequate positioning of the beam. Measurements were carried out using excitation wavelengths of 532 nm (Nd:YAG laser), 633 nm (He:Ne laser), and 785 nm (diode laser). Laser power was 50 mW, with a 60 second acquisition time, at various resolutions (2–4 cm^{-1}) in the range from 200 to 2000 (sometimes up to 4000) cm^{-1}. To confirm the results, we took measurements on at least two different points of each gemstone.

Results and Discussion. The ciborium contains 17 colored stones—10 pinkish red, four orange, and three light blue—mounted in metal settings that are attached to the body and lid. Its total weight is 1,350 g, and its height is 33 cm (about 13 in.). All the gems are held in closed-back settings; thus, their faceting arrangements were identified only from the crown. They were polished in near-round, rectangular, octagonal, and cushion shapes (all the light blue stones had slightly domed tables; e.g., figure 4), with one step of parallel facets on the crown. Table 1 provides a summary of the sizes, colors, and shapes/cuts. No indications of doublets, imitations, glasses, or synthetics were observed with magnification.

Raman spectroscopy demonstrated that all 10 red stones were Al-garnets. Father Tonassini had described these stones as rubies. All four orange stones were Ca-garnets. These were identified by Father Tonassini as "hyacinth" (an archaic term for red-orange-yellow zircon). Although some slight differences in the spectra of the 10 Al- and four Ca-garnets were observed (reflecting differences in composition), all were close to almandine and grossular, respectively (see table DD-1 and figure DD-1 in the *G&G* Data Depository at gia.edu/gandg; for more information regarding the semiquantitative analysis of garnets, see Smith [2005] and Bersani et al. [2009] and references therein).

Figure 1. This gold and gem-set ciborium (33 cm high), which dates from the end of the 16th century, is part of the treasures of Einsiedeln Abbey in Switzerland. Photo by Donat Stuppan, Swiss National Museum.

The blue stones all showed the main characteristic vibration band of corundum at about 415 cm^{-1}. Additionally, bands at 1400 and 1370 cm^{-1} were observed with 633 nm excitation; these are the characteristic Cr photoluminescence emission bands of corundum (see figure DD-2 in the *G&G* Data

Figure 2. The ciborium (left) is mentioned in an 18th century inventory (right) prepared by Father Eustache Tonassini. Photos by Hanspeter Lanz, Swiss National Museum (left), and Franz Kälin, Einsiedeln Abbey (right).

Depository). Father Tonassini correctly identified these stones as sapphires.

The EDXRF results for the six stones analyzed were in agreement with the Raman data. Different points on the metal were also analyzed and found to contain 82–85% gold, 7–8% silver, and 6–9% copper. No evidence was observed that any of the stones had been removed after they were originally set.

All the garnets were inert to UV radiation. The three sapphires fluoresced faint orange-yellow to long-wave UV and faint orange to short-wave UV. With magnification, the almandines showed mainly rutile needle–like inclusions and zircons, while the grossulars contained negative crystals and healed

Figure 3. A Raman spectrometer with an L-shaped lens was used to take spectra on the mounted ciborium gems (inset), which were difficult to access with conventional equipment. All the stones were conclusively identified with this instrument. Photos by Michael Wörle.

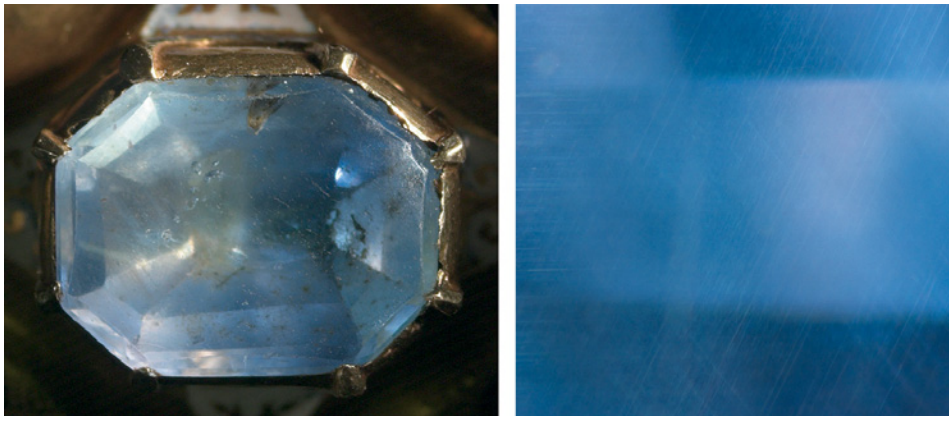

Figure 4. Sapphire KS1 (see table 1), like the other sapphires in the ciborium, has a slightly domed table (left; stone is 10.4 mm wide) and rutile needle-like inclusions (right; field of view ~90 μm). Photos by Marie Wörle.

fissures. In the sapphires we saw mainly rutile needles (figure 4, right), fissures, negative crystals, and black particles. Taking into account when these stones were set and the oriental origin mentioned by Father Tonassini, Sri Lanka is the most probable source. The inclusions in these sapphires are consistent with sapphires from that island nation. At the time, garnets were also known from the same region (as well as from India). However, more research with other methods and reference materials would be necessary to build a comprehensive database with which to compare these samples.

Conclusion. The Einsiedeln ciborium is decorated with 17 colored stones, all of which have old cuts and are natural. We saw no evidence that any were doublets or imitations, contrary to studies on other historical objects (e.g., Hänni et al., 1998, and references therein). Using Raman spectroscopy, we found that 10 were almandine (identified by Father Tonassini as rubies), four grossular (originally identified as hyacinths) and three were sapphires (identified by Father Tonassini as such). Further research would be needed to confirm the geographic origins, though Sri Lanka is possible.

TABLE 1. Characteristics of the colored gems set in the ciborium from Einsiedeln Abbey.

Number[a]	Color	Shape/Cut	Measurements (crown; mm)	Identification	
				This study	Tonassini (1794–98)
CN1S1	Pinkish red	Modified rectangular/step	5.9 × 5.6	Almandine	Ruby
CN1S2	Pinkish red	Near round/step	5.4 × 5.2	Almandine	Ruby
CN1S3	Pinkish red	Near round/step	5.2 × 4.9	Almandine	Ruby
CN1S4	Pinkish red	Modified rectangular/step	3.7 × 3.5	Almandine	Ruby
CN1S5	Pinkish red	Modified rectangular/step	4.4 × 3.4	Almandine	Ruby
CN2S1	Orange	Modified rectangular/step	7.4 × 6.3	Grossular	Hyacinth
CN2S2	Pinkish red	Near round/step	5.5 × 5.2	Almandine	Ruby
CN2S3	Pinkish red	Near round/step	5.2 × 4.7	Almandine	Ruby
CN2S4	Orange	Near round/step	5.5 × 5.4	Grossular	Hyacinth
CN2S5	Pinkish red	Oval/step	5.1 × 4.7	Almandine	Ruby
CN2S6	Pinkish red	Modified rectangular/step	7.6 × 6.0	Almandine	Ruby
KS1	Light blue	Octagonal/step	10.4 × 9.0	Sapphire	Sapphire
KS2	Orange	Modified rectangular/step	10.0 × 7.3	Grossular	Hyacinth
KS3	Light blue	Octagonal/step	10.1 × 8.0	Sapphire	Sapphire
KS4	Orange	Octagonal/step	13.3 × 10.0	Grossular	Hyacinth
KS5	Light blue	Octagonal/step	12.4 × 9.7	Sapphire	Sapphire
KS6	Pinkish red	Oval/cabochon	13.9 × 10.7	Almandine	Ruby

[a]*The numbering of the stones begins from the stamp of Einsiedeln and proceeds clockwise: C indicates the lid, K the body, and S the stone. On the lid, two levels are present: N1 for the upper level and N2 for the lower. For example, stone CN2S5 is in the lid, in the second level, the fifth stone clockwise from the Einsiedeln stamp.*

ABOUT THE AUTHORS

Dr. Karampelas (s.karampelas@gubelingemlab.ch) is a research scientist and Mrs. Gübelin is a gemologist at Gübelin Gem Lab, Lucerne, Switzerland. Dr. Wörle is head of conservation research, Mrs. Hunger is an archeometrist, and Dr. Lanz is a curator at the Swiss National Museum, Zurich. Dr. Bersani is a researcher in the physics department at the University of Parma, Italy.

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