Facets of Light: The Case of Rock Crystals

Anna Contadini
This essay concentrates on the production of rock crystal during the Fatimid rule in Egypt (909–1171), which has given us—both in number and quality—the most impressive extant Islamic rock crystal. Alongside a review of sources, it pursues three main areas of enquiry: the physical nature of the material itself, the techniques of manufacture, and the cultural meanings that might have been attached to the light properties of rock crystal objects.

Rock crystal (Arabic: bizarra) is a type of quartz, with the transparent variety called hyaline quartz. Found all over the world, rock crystal is one of the most ancient minerals in the earth’s crust, occurring in hexagonal crystals of different dimensions. For classical authorities the combination of crystalline structure and transparency was equated with ice, and because of this a cooling effect was ascribed to rock crystal, with the corollary that crystal vessels could not tolerate heat. It is in fact the case that rock crystal is a poor heat conductor, so that if only part of a crystal is heated, the other part remains relatively cool, thus creating tension. With Cook, former head of Sculpture Conservation at the Victoria and Albert Museum (V&A), I conducted an experiment in which a rock crystal was half buried in sand and the exposed part was heated. At about 100 degrees the part splintered, breaking off along the fracture planes at the point between the buried and the exposed parts.

Whether a rock crystal vessel breaks when dropped is determined by whether or not a fracture plane is present. If it does, it shatters into many pieces, as demonstrated by the ewer in Figure 90, carved in relief and datable by the inscription to 1000–89. In an unfortunate accident, it broke along the fracture planes into some 80 fragments. Despite the assertion by Pliny (first century AD) that “once it has been broken, rock crystal cannot be repaired” (Pliny 1662, Book 37, 185), the Pitti ewer was reassembled in Florence’s famous Studio delle Pietre Dure through a complex process of assembling involving the use of cyanacrylate resin (Cappelli 2008). However, although the pieces were repaired, the way that the crystal with its relief reflects and refracts the light is permanently altered (pl. 91).

If one thinks of the size of rock crystal ewers in which the handle is integral to the body, it is clear that crystals of huge size must have been used for these ewers. In his treatise, Kitab al-Hadaya wa‘l-Tuhaf of Book of Gifts and Rarities, pieces even larger than the ewers are mentioned (trans. al-Qaddami 1996, 238–39, paragraphs 40 and 404 respectively):

Nasir al-Juyini also acquired [from the palace treasures] a spouted ewer [unengraved] smooth rock crystal fashioned like the bronze (nukhat) ones [usually] to be attached to [water] storage jars with conical bases (246). Its handle was from the same block [of rock crystal]. The spouted ewer carried ten Egyptian water. (The fabric of its case (nauhah) was adorned all over with precious stones.)

Facets of Light
This essay concentrates on the production of rock crystal during the period of Fatimid rule in Egypt (969–1171), which has given us—both in number and in quality—the most impressive extant Islamic rock crystals. Alongside a review of the sources, it pursues three main areas of enquiry: the physical nature of the substance itself, the techniques of manufacture, and the cultural meanings that might have been attached to the light properties of rock crystal objects.

Rock crystal (Arabic: hubhān) is a type of quartz, with the transparent variety also called beryl quarts. Found all over the world, rock crystal is one of the most common minerals in the earth’s crust, occurring in hexagonal crystals of different dimensions. For classical authorities the combination of crystalline structure and translucency suggested an analogy with ice, and because of this a cooling effect was worked to rock crystal, with the corollary that crystal vessels could not tolerate heat. It is in fact correct to say that rock crystal is a poor heat conductor, so that if only part of a crystal object is heated, the other part remains relatively cool, thus creating tension. With Richard Cook, former head of Sculpture Conservation at the Victoria and Albert Museum (V&A), I conducted an experiment in which a rock crystal was half buried in sand and the exposed part was heated. At about 100 degrees part of it splintered off and at about 230 degrees it exploded, breaking off along the fracture planes at exactly the point between the buried and the exposed parts.

Whether a rock crystal vessel breaks when dropped is determined by whether it has a fracture plane on impact. If it does, it shatters into many pieces, as demonstrated by the ewer (pl. 90), carved in relief and datable by the inscription to 1006–68, in the Museo degli Argenti of Palazzo Pitti (Rice 1950: in an unfortunate accident in 1968 it broke along the fracture planes into some 80 fragments. Despite the assertion by Plan (first century CE) that “once it has been broken, rock crystal cannot be mended by any method whatsoever” (Pliny 1962, Book 37, 185), the Pitti ewer was restored by Florence’s famous Opticico delle Pietre Dure through a complex program of assemblage involving the use of cyanosynlate resin (Cappelli 2008). However, although expertly repaired, the way that the crystal with its relief reflects and refracts the light has been permanently altered (pl. 91).

If one thinks of the size of rock crystal ewers in which the handle is integral to the body, it is clear that crystals of huge size must have been found on occasion. Ibn al-Zubayr, judge during the reign of the Fatimid caliph al-Mustazir (r. 1036–04), speaks of a multitude of rock crystal vessels in the palace treasury, many of them of large size. In his treatise, Kitab al-Hadaya wa-l-Talab or Book of Gifts and Rarities, pieces even larger than the ewers are mentioned (trans. al-Qaddumi 1995, 238–39, paragraphs 409, 402, and 454 respectively):

Nasir al-Jawhar also acquired [from the palace treasury] a spouted ewer (kaw) of [unengraved] smooth rock crystal fashioned like the bronze (minal) one [usually] made [to be attached] to [water] storage jars with conical bases (cab). Its handle was carved from the same block of [rock crystal]. The spouted ewer carried two Egyptian mugs of water. [The fabric of] its case (tisawān) was adorned all over with precious pearls…
Nairi al-Dryshah acquired a large storage jar (qatnaqis) of rock crystal with images (sumar) carved in [high] relief (nabihah ‘an jismih) and having a [liquid] capacity of seventeen sath...

A large box (majma) for [keeping] appetizer saucers (sakaniy) [was found] with its cover (giba) cut with a lathe (malubdah) from a [single] block of rock crystal. It contained appetizer saucers of rock crystal, which could be removed and put back into it. It was four spans by four of beautiful workmanship (al-sahib).

Smaller pieces were used to fashion a great variety of artifacts, from dishes to chess pieces (Contadini 1995, fig. 43; Cusano 2006, 79, cat. 43; pl. 92a-c) and seals (Settel 1998, 131-32, cat. 103; pl. 93) to little perfume or make-up holders in the shape of creatures such as fish or lions (Arts Council of Great Britain 1996, 123, cat. 103; pl. 89) and bottles of various shapes (Contadini 1998, 37, pl. 4; pl. 94a-b).

The treasury was looted and dispersed during the social unrest in the 1600s, and according to the Marlik chronicler al-Maqrizi (1264-1442) a vast number of rock crystal pieces came onto the market: he mentions a (most probably inflated) figure of 18,000 pieces, fetching from 10 to 1,000 dinars each, an enormous sum (al-Maqrizi 1853, 1:414: Kahl 1935, 340). In many instances al-Maqrizi remarks upon their huge size, capacity (up to 9 naths, about 5 liters), but his descriptions unfortunately give no notion of the technique or style of decoration and are not precise enough to identification with extant rock crystals. Nevertheless, when he mentions two piec rock crystal from the treasury that a "reliable witness" had seen in Tripoli as "ex in purity and beauty of craftsmanship, one of them a ewer and the other a jar with the name al-'Aziz bi'llah written on the side of each one" (al-Maqrizi 1853, I:414: Kahl 1935, 345; Erdmann 1951, p. 15), one is tempted to think that the ewer be the "Aziz ewer now in the treasury of St. Mark in Venice (Hahnloser 1971, 11 cat. 124; pls. XCVIII-X, pl. 93a-b).

Several authorities ascribe magical and healing powers to rock crystal, but all so ancient and medieval, Arabic and European, remark upon its light properties: Pliny, for whom rock crystal is incomparable for its transparency and has also comments on its ability to split light into a spectrum (Pliny 1962, Book 37). The great Iranian polymath al-Biruni (973-1048), who wrote a treatise on the entitled Kitiš al-janahir fi ma ri‘ayat al-janahir, tells us that rock crystal "is notable for [clarity, resembling the two essential elements of life, air and water]" (al-Biruni 1976, Facets of Light 128: God Is the Light of the Heavens and the Earth)
Nair al-Dawlah acquired a large storage jar (gatamīs) of rock crystal with images (sana) carved in [high] relief (nudhāth 'am jarāqah) and having a [liquid] capacity of seventeen sah...

A large box (magūna) for [keeping] appetizer saucers (sakari) [was found] with its cover (ghārā) cut with a lathe (madār) from a (single) block of rock crystal. It contained appetizer saucers of rock crystal, which could be removed and put back into it. It was four spans by four of beautiful workmanship (ul-san'ah).

Smaller pieces were used to fashion a great variety of artifacts, from dishes to chess pieces (Contadini 1995, fig. 4); Curatola 2010, 79, cit. 43; pl. 92a-c) and seals (Seipel 1998, 131-32, cat. 103; pl. 93) to little perfume or make-up holders in the shape of creatures such as fish or lions (Arts Council of Great Britain 1996, 123, cat. 107; pl. 89) and bottles of various shapes (Contadini 1995, 37, pl. 2, pl. 94a-b).

The treasury was looted and dispersed during social unrest in the 1960s, and according to the Mamluk chronicler al-Maqrizi (1364-1442) a vast number of rock crystal pieces came onto the market: he mentions a (most probably inflated) figure of 18,000 pieces, fetching from 10 to 1,000 dinars each, an enormous sum (al-Maqrizi 1833, i: 94a-b). (65) Carved rock crystal bottle, 975-1050, Egypt, Cairo (i). h. 14.8 cm with base, diam. 3.1 cm (reconstructed base). Victoria and Albert Museum (A.33-1928); b: (right) detail of pl. 94a-b.

414; Kahle 1934, 240). In many instances al-Maqrizi remarks upon their huge size or capacity (up to 9 sah, about 5 liters), but his descriptions unfortunately give no indication of the technique or style of decoration and are not precise enough to allow identification with extant rock crystals. Nevertheless, when he mentions two pieces of rock crystal from the treasury that a "reliable witness" had seen in Tripoli as "extreme in purity and beauty of craftsmanship, one of them a ewer and the other a jar with the name al-"Aziz bi'llah written on the side of each one" (al-Maqrizi 1833, i: 414; see also Kahle 1934, 345; Erdmann 1951, n. 15), one is tempted to think that the ewer could be the al-"Aziz ewer now in the treasury of St. Mark in Venice (Hahnloser: 1907, 112-13, cat. 124, pls. XCVIII-IX; pl. 95a-b).

Several authorities ascribe magical and healing powers to rock crystal, but all sources, ancient and medieval, Arabic and European, remark upon its light properties. For example, Pliny, for whom rock crystal is incomparable for its transparency and hardness, also comments on its ability to split light into a spectrum (Pliny 1966, Book 37, 275). The great Iranian polymath al-Biruni (973-1048), who wrote a treatise on minerals entitled Kitab al-jamahir fi ma'rifat al-jamahir, tells us that rock crystal "is notable for its clarity, resembling the two essential elements of life, air and water" (al-Biruni 1936, 183).
and notes that "when sunlight strikes it the colors of the rainbow become visible" (ibid., 185). He speaks of high quality rock crystal being imported from the "Isles of Zanj" (East Africa) and from al-Dabja (the Laccadive and Maldives Islands in the Indian Ocean) to Basra in Iraq where it was worked by local craftsmen. Al-Biruni also quotes other Arab authorities, including al-Khindi (d. 866), for whom the best rock crystal in terms of clarity is the Arabian one. Al-Biruni mentions other sources in the Panjir (Wakh in present-day Afghanistan and Badakshan in present-day south Tajikistan), Kashmir, and Sri Lanka, but states that there is no demand for the rock crystal from the Panjir, while that from Kashmir and Sri Lanka is inferior in quality, being less translucent (Al-Biruni 1995, 184; also Kahl 1996, 332–34). Nasir-i Khusraw, the Iranian traveler writing in the mid-eleventh century, tells us that unworked crystal from the Maghrib was being replaced by finer quality, more translucent material from Qazwin (modern Suez) on the Red Sea, and he also gives an eyewitness account of beautiful rock crystal objects being worked in relief in the house of Fatimid Cairo (Nasir-i Khusraw 1881, 140). The North African anthologist al-Tifashi (1184–1252), who wrote a comprehensive treatise on the use of minerals, Kitab Asdar al-Ahkam fi Tanzil al-Ahkam, says that at thirteen days' journey from Kashgar there are two mountains whose interior consists entirely of beautiful rock crystal; it is worked at night, as the reflection of the sun's rays renders work by day imposable (al-Tifashi 1977, 202). While employing various light properties, translucency, polarization, and, in the last case, a blinding luster, these writers thus offer information on a wide range of sources of rock crystal in the Islamic period, references to two centers (Basra and Cairo) for the working of rock crystal in the tenth and eleventh centuries, and decided opinions about quality, all based on the clarity and translucency of the crystal.

Another aspect mentioned by al-Biruni is the way in which the carving of the rock crystal reveals imperfections such as cloudiness or cracks (Al-Biruni 1995, 184), which are sometimes accentuated by the light. For example, a fragment of a small cylindrical bottle in the V&A (pl. 96a), dated to the first half of the eleventh century, includes an abbreviated inscription carved in relief that invokes blessing for the owner, kustisa li-wahibhi (Contadini 1998, 37). Although a hair-line crack can just be discerned by the naked eye, the photographic techniques of raking light and Dino-Lite show that the magnified area covers the depth of the crack, which appears black to the eye. These cracks function as a barrier to light, creating a dark area (pl. 96b).

Carving in relief produces surfaces at different angles to the body, thereby creating complex reflections, refraction, and also florescence where the light striking the surface breaks into the rainbow spectrum. These effects contribute to make rock crystal vibrant, as the light travels in different directions. The complex angles and refractions created by the carving can be seen clearly from photos taken at a magnification of 80%, which also show the resulting effects on the light as it hits the surface (pl. 96c). The best piece, those made between the late tenth and eleventh century exhibit evident different types of cut: perpendicular, at 45 degrees, higher an relief, semi-spherical, and incised vertical and horizontal lines of varying length. Some of the more complex pieces also show the so-called "line and dot" motif (Contadini 1998, 37–38, pl. 7, pl. 97a–b).

Despite the abundance of Islamic rock crystal, what we know of the history of the use of the stone is based upon production in the Near East. But general principles may be derived from early seventeenth-century German accounts of the use of rock crystal and the accounts of the French jewelers Jannier and Chardin, who describe the cutter's craft during the seventeenth century in India and Iran respectively (T2).
sun's rays renders work by day impossible (al-Tifashi 1977, 202). While emphasizing various light properties, translucency, polarization, and, in the last case, a blinding brilliance, these writers thus offer information on a wide range of sources of supply in the Islamic period, references to two centers (Barra and Cairo) for the working of rock crystal in the tenth and eleventh centuries, and decided opinions about variations in quality, all based on the clarity and translucency of the crystal.

Another aspect mentioned by al-Biruni is the way in which the carving of the crystal might conceal imperfections such as cloudiness or cracks (al-Biruni 1936, 184). For the ways in which these alter the reflection and refraction of the light we may take as an example a fragment of a small cylindrical bottle in the V&A (pl. 96a), datable to the first half of the eleventh century, with an abbreviated inscription carved in relief around it that invokes blessing for the owner, banaka bi-sahabih (Contadini 1998, 37, pl. 5). Although a hair-line crack can just be discerned by the naked eye, the photographic techniques of taking light and Dino-Lite show that the magnified area corresponding to the depth of the crack appears black: the crack functions as a barrier to the light, creating a dark area (pl. 96b).1

Carving in relief produces surfaces at different angles to the body, thereby causing complex reflections, refraction, and also fluorescence where the light striking the crystal breaks into the rainbow spectrum. These effects contribute to make rock crystal objects vibrant, as the light travels in different directions. The complex angles and curves created by the carving can be seen clearly from photos taken at a magnification of circa 80%, which also show the resulting effects on the light as it hits the surface of the vessel (pl. 96c). The best pieces, those made between the late tenth and eleventh century, exhibit several different types of cut: perpendicular, at 45 degrees, higher and lower relief, semi-spherical dots, and incised vertical and horizontal lines of varying width. Some of the more complex pieces also show the so-called "line and dot" motif, as in the V&A rock crystal ewer (Contadini 1998, 37–38, pl. 7; pl. 97a–c).

Despite the abundance of Islamic rock crystals, what we know of the history of the techniques of carving is not based upon production in the Near East. Rather, the general principles may be derived from early seventeenth-century German treatises; accounts of traditional German, Indian, and Chinese lapidaries; iconographic evidence; and the accounts of the French jewelers Tavernier and Chardin, who describe the gem cutter's craft during the seventeenth century in India and Iran respectively (Tavernier

and notes that "when sunlight strikes it the colors of the rainbow become visible" (ibid., 185). He speaks of high quality rock crystal being imported from the "Isles of Zanz" (East Africa) and from al-Dhajaj (the Laccadive and Maldives Islands in the Indian Ocean) to Barra in Iraq where it was sold by local craftsmen. Al-Biruni also quotes earlier Arab authorities, including al-Kindi (d. c. 866), for whom the best rock crystal in terms of clarity is the Arabian one. Al-Biruni mentions other sources in the Pamirs (Wakhlan in present-day Afghanistan and Badakhshan in present-day Tajikistan), Kashmir, and Sri Lanka, but states that there is no demand for the rock crystal from the Pamirs, while that from Kashmir and Sri Lanka is inferior in quality, being less translucent (al-Biruni 1936, 184; also Kähle 1976, 332–34). Nasi-i Khosrow, the Iranian traveler writing in the mid-eleventh century, tells us that unworked crystal from the Maghrib was being replaced by finer quality, more translucent material from Qulsum (modern Susa) on the Red Sea, and he also gives an eyewitness account of beautiful rock crystal objects being worked in relief in the bazaar of Fatimid Cairo (Nasi-i Khosrow 1881, 140). The North African archaeologist al-Tifashi (1184–1255), who wrote a comprehensive treatise on the use of minerals, Kitab Azkar al-Ajhar fi Jawahir al-Ajhar, says that at thirteen days' journey from Kashgar there are two mountains whose interior consists entirely of beautiful rock crystal; it is worked at night, as the reflection of the

96a (left) Fragment of cylindrical rock crystal bottle (perfume or make-up holder) with a circular boring in the middle, first half of 10th century, Egypt, h. 10 cm at highest point. diam. 8.7 cm. Victoria and Albert Museum (A.11-1942).

96b (middle) Detail of the bottle in pl. 96a, photographed at taking light magnification, showing, on the right, how the crack functions as a barrier to the light and creates a dark area. Victoria and Albert Museum (A.11-1942).

96c (right) Detail of pl. 96a, with part of the inscription ("Bakha bi-l-sahibih") carved in relief around the body of the bottle. Photographed under Dino-Lite at 80% magnification, it shows the effects of the light as it hits the surface. Victoria and Albert Museum (A.11-1942).
Rock crystal ewer, shown in four different views and a detail, 11th century, Egypt. h. 29.5 cm, diam. of belly c. 14 cm. Vienna and Albert Museum (1904-1865).

1678, Part 2, Bk. 2, 134–35; Chardin 1811, IV: 4, 142–43) as well as by checking these findings against the experience of a contemporary stone carver who is particularly interested in rock crystal. A first basic question concerns not the surface but how a rock crystal was hollowed out: the ewer in the V&A, for example, is extraordinarily thin in relation to its size, and the only opening, the mouth, is very small in relation to the size of the belly. The technique can be reconstructed as follows (pl. 98): the shape of the vessel was first roughly cut with a saw and shaped by chipping with a small hammer (a technique still employed), and a hollow cylindrical tool was then used to make an opening. This tool must have been of hard metal, quite possibly, as today, of steel, which was used in the Arab Middle East already in the tenth century and in Iran in the ninth, as the Merv excavations have shown (Hermann et al. 1996; Simpson 2001). Used in combination with an abrasive, probably of water and sand, the tool was rotated, possibly with a bow drill, in order to start penetrating into the rock crystal. Once the tool had reached a sufficient depth, a sharp tap would be enough to snap off the crystal core inside, which could then be extracted together with the tool. This done, the cavity was extended to the required depth by a drill attached to a bow lathe. In order to widen the cavity, a steel wire or a group of steel wires was then introduced in the central hole; when pressed, the wires would curve and, with the help of an abrasive, would be rotated to scratch away the inner wall until the interior of the vessel was carved out as required. A smooth finish could have been achieved by introducing through the aperture pebbles and an abrasive, such as sand or diamond dust and water, or hematite, a good polisher, and then turning the object so that centrifugal force would press and rotate the abrasive against the inner walls (Costadini 1999).
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The above operations are all very delicate, requiring great skill and a thorough understanding of the fracture planes of the mineral. Once completed, the working of the outer surface could commence, using a bow-lathe with a fixed spindle to one end of which was attached either a drill or a small wheel. One hand rotated the spindle by pushing the bow backward and forward while the other hand (or in the case of the ewers, probably more than one hand) grasped the crystal, manipulating it against the drill or disk. The use of the term mahmut (lathe) in the quotation from the Kitáb al-Hadíyát cited above is consonant with such a technique. This operation is also depicted in process on the margin of a page from the album of paintings made for the Mughal emperor Jahangir in about 1610–11: it shows a lapidary using the bow drill to cut a ruby (pl. 99). The choice of wheel would determine the type of cut and the angle of the relief in relation to the body (pl. 100). The same technique had been used in the ancient world for cutting not only other hardstones such as agate and sardonyx...
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but also glass. It seems likely that glass cutting was inspired by hardstone carving, and the two industries could well have existed side by side. A rock crystal carver has confirmed that the above scenario is plausible, as contemporary carvers use a very similar technology, the only difference being that the process is power driven. Plates 112–13 show the cylindrical metal instruments that he uses to make the opening in the stone; the tool and wheels of various sizes for cutting, made of a soft metal like copper and used with an abrasive powder around the outer edge of the wheel; and the power-driven drill to which the tools are attached. During the cutting, cold running water is used not just to flush out the powder it produces but also, and especially, to cool the wheel, as the process generates considerable heat (pl. 104).

Complex cutting techniques involving different angles of cut may be used to maximize the capturing and reflection of light, making the object appear vibrant and alive. The Keir ewer (pl. 103a), for example, an extraordinary piece that was sold at Christie's in 2008 with its nineteenth-century French gilded and enamelled mount, is very lustrous and has been polished to a high degree (Christie's 2008; Weber 2011). The mount includes cheetahs with a collar with link-chains (pl. 105b), with the outer cheetahs in relief, while the actual body of the animal is at the same level as the undecorated surroundings (pl. 105c). The risk in cutting dots into the very lustrous body area was therefore considerable. A similar approach is to be found on so-called 'Venetian' cutting carved in relief, as shown by the beautiful and large clear glass bowl in the treasury of St Mark, Venice (pl. 106), where the contours of the lions are in high relief, and the bodies of the lions are not (Hahnloser 1971, 197–98, cat. 120, pl. XCIV) whereas on others such as the V&A ewer and a flask in the Keir collection (Pinder-Wilson 1980, col. pl. 62), the animals and vegetal motifs are carved from an area that is at the same level as the surrounding background (pl. 107a–b). This technique is also found in a glass, as on the turquoise glass bowl in the treasury of St Mark (Hahnloser 1974, cat. 117, pl. LXXXIX–XC). Here, again, the whole area of the hare stands out from the lower background (pl. 108).
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A rock crystal carver has confirmed that the above scenario is plausible, as contemporary carvers use a very similar technology, the only difference being that the process is power driven. Plates 101–03 show the cylindrical metal instruments that he uses to make the opening in the stone; the tools and wheels of various sizes for carving, made of soft metal like copper and used with an abrasive powder around the outer edge of the wheel; and the power-driven drill to which the tools are attached. During the cutting, cold running water is used not just to flush out the powder it produces but also, and especially, to cool the wheel, as the process generates considerable heat (pl. 104).

Complex carving techniques involving different angles of cut may be used to maximize the capturing and reflection of light, making the object appear vibrant and alive. The Keir ewer (pl. 105), for example, an extraordinary piece that was sold at Christie’s in 2008 with its nineteenth-century French gilded and enamelled mount, is very translucent and has been polished to a high degree (Christie’s 2008; Weber 2011). Its decoration includes cheetahs with a collar with link-chains (pl. 106), with the outlines of the cheetahs in relief, while the actual body of the animal is at the same level as the undecorated surroundings (pl. 107). The risk run in carving dots into the very thin body area was therefore considerable. A similar approach is to be found on some glass carved in relief, as shown by the beautiful and large clear glass bowl in the treasury of St. Mark, Venice (pl. 106), where the contours of the lions are in high relief but the bodies are not (Hahnloser 1971, 107–08, cat. 120, pl. XCVI) whereas on other objects, such as the V&A ewer and a flask in the Keir collection (Pinder-Wilson 1988, 303–05, col. pl. 62), the animals and vegetal motifs are carved from an area that is at a higher level than the surrounding background (pl. 75a–b). This technique is also used on glass, as on the turquoise glass bowl in the treasury of St. Mark (Hahnloser 1971, 103–04, cat. 17, pls. LXXXIX–XC). Here, again, the whole area of the horses stand out in relief from the lower background (pl. 108).
Ibn al-Haytham (d. 1039), who actually lived in Fatimid Cairo, wrote a Kitāb al-Manazzil (Book of Optics), which includes a section on transparent objects. In his discussions on rock crystal and glass, he repeatedly states that light can play through a thinly made arid transparent body (Ibn al-Haytham 1989, I: 332–40), and the best rock crystal vessels are thin indeed. I was able to measure the V&A ewer (see pl. 572–e) which, excepting the slightly thicker lower part, has an average thickness of 1.7 mm for the ground body and just over 2 mm for the parts with the relief decoration. Measuring 19.5 cm high, with the diameter of the belly at about 14 cm, the ewer weighs about half a kilo.

The al-Aziz and related ewers, which date to the late quarter of the tenth century, represent a pinnacle of artistic achievement. But the challenges faced by their Fatimid carvers were by no means novel. Rock crystal had been fashioned into objects of particular rarity since classical times, and in the central Islamic lands it had probably been carved from the very rise of Islam in the seventh century, so that the outstanding skills of the Fatimid craftsmen mark the culmination of a centuries-old tradition of artisanal expertise. For both stone carving (such as agates) and glass cutting we know of long-standing production in Iran, Egypt, Syria, and other regions, although we unfortunately know little about its evolution, and its economic (and social) structure during the Fatimid period also remains obscure. However, we do have some information from al-Biruni, who tells us that “in Basra the rough crystal is first seen by an ascensor (al-mu‘āddib), who decides what would be the best objects to make out of the big and small pieces and writes this on each of them” (al-Biruni 1936, 184). He goes on to tell us that the pieces are then taken to the craftsman to carve. Interestingly, the
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larger fee goes to the assessor, reflecting the superiority of concept over execution (al-Biruni 1936, 184; also Kahle 1935, 332). From Nasir-i Khusraw's remarks on the carving and sale of rock crystal in the Cairo bazaar, we can at least infer that there were commercial workshops most probably producing wares for a variety of customers, and it is reasonable to suppose that their organization and hierarchy were similar to what al-Biruni describes.

Unfortunately, the high level of craftsmanship exhibited by the Fatimid ewers was not sustained in the Islamic world, and from the eleventh century production declined, if without ceasing completely. The craft continued in Byzantine territories, and carved rock crystal (Ancaloro 2006, I: 338–39, cat. V.131; pl. 109) and carved glass such as the Hedwig glasses (Tait 1995, 126–27, figs. 158–59; pl. 110) have been variously attributed to Sicily during the second half of the twelfth century and Burgundy during the thirteenth and fourteenth centuries. Later, the craft was revived under Mughal patronage in India—The V&A holds a number of objects from the reign of the emperor Shah Jahan (r. 1628–58), as well as those that show how the tradition of relief carving
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Rock crystal cup with floral design cut in relief, 18th century. Mughal India. h. 3.8 cm, w. 5.7 cm, d. 3.7 cm. Victoria and Albert Museum (1976-11-15).

Continues later, as demonstrated by an eighteenth-century cup (Kozmicka 1993, 49, cat. 23; pl. 111). The craft was also practiced in Ottoman Turkey, where, as in the Mughal courts, rock crystal objects were often inlaid with gemstones and gold (Rogers and Köseoğlu 1987, 43). For instance, a sixteenth- or seventeenth-century horn or tortoiseshell comb (pl. 112) has a rock crystal handle (Ard 1990, 301, cat. 102; Komaroff 2001, 210, cat. 13, fig. 140), and the treasury of the Topkapı Palace includes a rock crystal chess set inlaid with emeralds and rubies to distinguish the opposing sides (Rogers and Köseoğlu 1987, 206-07, cat. 120; Bernis Taylor 1990; Mackenzie and Finkel 2004, fig. 12.3; pl. 113). In Europe, apart from the workmanship, the properties of clarity and translucency made rock crystal an attractive material for reliquaries (Connahini 2000, pl. 115). The emphasis on bright colors in such later developments stands in stark aesthetic contrast to the play of light upon the undecorated rock crystal of the intricately carved Fatimid ewers.

As Kapstein (2004, Preface, xi) states: “Light may be either physical or spiritual and therefore is an object both of physics and of religious reflection…. ‘Light’ may literally refer to sensory experience, but at the same time it offers one of our most far-reaching metaphors: knowledge is light, its acquisition enlightenment.” Integral to the reading of these objects is a consideration of their reception, beyond the purely aesthetic, as potential bearers of symbolic meaning. The association of God and light and the notion of divine illumination are ubiquitous, so that one of the questions we face in relation to Middle Eastern rock crystals and the Fatimid ewers in particular is whether we are dealing with a substance where the always latent potential of its physical properties for
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metaphorical play was acted out programmatically, so that in its extreme case its light was held to represent or even embody that associated with the caliph himself. The ancient idea of the divine right of kingship (a doctrine of royal and political legitimacy also very well known to the Byzantines) appears, associated with light, in the writing of the Fatimid court paparazzi and Isma‘ili scholar Ibn Fadlan (d. 973), who conceives the Fatimid caliph al-Mu‘izz as a body of light fed by the radiance of the celestial world, with the light he gives forth being on a par with the divine light emanating from God (Canard 1994). But to what extent, we may wonder, did concepts that appear in Fatimid propaganda have purchase on general attitudes to material culture? In particular, could we speculate that rock crystal was widely perceived as a symbolically significant substance, one embodying the properties of light associated with the illumination that the caliph radiated?

Other scholars have detected an analogous perception in relation to the Mughal emperors, suggesting “a concern for adapting religious symbolism, especially elements associated with light and auspicious sight, to an iconography of royalty” (Asher 2004, 161). In support of this connection, reference is made to the tomb of the saint Mu‘in al-Din in Ajmer, whose dome was given a marble facing in 1579, while a Persian inscription on the interior points to white marble being a metaphor for God; and the historian Abu’l-Fazl, who traces Akbar’s lineage from Adam through the prop to a Mughal princess, Alanqwa, who, like the Virgin Mary, is miraculously impregnated by a ray of divine light.

However, the surviving documentation relating to the Fatimid examples fails to suggest parallels for the kinds of inferences detected by Catherine Asher for the Mughals (Asher 2004). Efforts to reconstruct a “period style” could call upon three of the mental processing of sense data as articulated by, say, the Ikhwan al-Safa’ on Sina, but their reflex in later Byzantine texts commenting on images (Dammini 2003) is not matched in the surviving corpus of Arabic texts. Without such a prolongation they remain too abstract and distant to yield clues as to the specific cultural means that rock crystal may have possessed in Fatimid Cairo.

For the Fatimid ewers, it would be safer to consider the evidence of the inscription upon them. The one in the Louvre (pl. 114) has a dedicatory inscription of a type found on many objects in different media and is in no way distinctive (Alcouffe 19
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However, the surviving documentation relating to the Fatimid examples fails to suggest parallels for the kinds of inferences detected by Catherine Asher for the Mughals (Asher 2004). Efforts to reconstruct a “period gaze” could call upon theories of the mental processing of sensory data as articulated by say, the Ikwam al-Safa or Ibn Sina, but their reflexes in later Byzantine texts commenting on images (Daniatos 2004) is not matched in the surviving corpus of Arabic texts. Without such a prolongation, they remain too abstract and distant to yield clues as to the specific cultural meanings that rock crystal may have possessed in Fatimid Cairo.

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That in Fermo (pl. 115) has along its shoulders banaka wa izzan bi'llah sallal al-mallah al-"Ismi (Andaloro 2006, I: 131–33, cat. 11.9); whether we associate it with a specific Manju just read it as "Blessing and joy to the victorious king," it is simply an express good wishes for a ruler. The inscription on the ewer in the Pitti Palace (see pl. 96) no more than dedicate it to the qa'il al-qawmi (commander of commanders), held on and off between 1000 and 1008 by the general Abu 'Abdullah al-Husayn served under the Fatimid caliph al-'Aziz and al-Hakim. Rather more substantial inscription incised on a crescent-shaped piece (pl. 116), probably used in imperial ceremonies (Coutardini 1999 and fig. 1). It includes the name of al-Zahir, the Fatimid who reigned from 1021 to 1036, and ends with atila allah sallal al-mallah, as standard as live the king!" The beginning of the inscription, b'llah al-'Ism (To God belongs the strikes a more religious note, and this tenor becomes more explicit in the inner on the magnificent ewer in the treasury of St. Mark (see pl. 95): banaka min al-"Ism al-'Aziz bi'llah (blessing from God on the Imam al-'Aziz b'llah), referring famous Fatimid caliph who reigned between 975 and 996. Such expressions are, nevertheless, stubbornly general, and there is still, even in this last case, no after light, nothing of ideological import that might remind one of Ibn al-Hani's dense of the Fatimid caliph. Indeed, the dramatic depictions of animals on the ewer do away from anything specifically dynastic and toward the doctrinally neutral visual of the princely cycle: a lion might signify that this is a ewer fit for a prince (if but the metaphorical understanding of a hunting scene, as in the V&A ewer, it us to add notions of spiritual radiance to those of power and domination (pl. 116).

But there are also, even if rare, rock crystal lamps. Given the inescapable need to the Qur'anic chapter of light (Sur 24), to the lamp with the light inside, one
That in Fermo (pl. 115) has along its shoulders *banba uss sar al-l-ayyid al-malik al-masamur* (Andaloro 2004, I: 131–33, cat. II.3); whether we associate it with a specific Mansur or just read it as “Blessing and joy to the victorious king” it is simply an expression of good wishes for a ruler. The inscription on the civer in the Piri Palace (see pl. 90) does no more than dedicate it to the *qa'id al-qanawit* (commander of commanders), a title held on and off between 1000 and 1008 by the general Abu 'Abd Allah al-Husayn, who served under the Fatimid caliphs al-'Aziz and al-Hakim. Rather more substantial is the inscription incised on a crescent-shaped piece (pl. 116), probably used in imperial ceremonies (Constandini 1999 and fig. 1). It includes the name of al-Zahir, the Fatimid caliph who reigned from 1021 to 1036, and ends with 'atid al-ahd ba'adih adi, as standard as “long live the king!” The beginning of the inscription, *lillah al-din* (To God belongs the faith), strikes a more religious note, and this tenor becomes more explicit in the inscription on the magnificent civer in the treasury of St. Mark (see pl. 95b); *banba wa al-ahd l'ilhah al-aziz lillah* (blessing from God on the Imam al-'Aziz lillah), referring to the famous Fatimid caliph who reigned between 995 and 1096. Such expressions remain, nevertheless, stubbornly general, and there it is still, even in this last case, no allusion to light, nothing of ideological import that might remind one of Ibn al-Farid's description of the Fatimid caliph. Indeed, the dramatic depictions of animals on the civer draw us away from anything specifically dynastic and toward the doctrinally neutral visual world of the princely cycle: a lion might signify that this is a civer fit for a prince (pl. 117), but the metaphorical understanding of a hunting scene, as in the VA civer, is unlikely to add notions of spiritual radiance to those of power and domination (pl. 118).

But there are also, even if rare, rock crystal lamps. Given the inescapable reference to the Qur'anic chapter of light (Sura 24), to the lamp with the light inside, one might
readily assume a Fatimid association not merely with divine light but also with that emanating from the caliph. Indeed, following Dewood's 1936 translation of this verse, some scholars have rendered zaqājā as "crystal" and then by a natural seeming transition have placed rock crystal at the center of the symbolism of light to which it gave rise (Shalem 1994, 5). But fundamentally zaqājā means glass, and while an obvious relationship with rock crystal can be posited, it is surely a question of association rather than identification. At most, one could assume by extension that the symbolic charge of the glass in this verse would encompass also rock crystal, and this equivalence could be supported by the similarity in the way both materials can be treated: clear glass cut in relief was produced at least as early as the ninth century, as Sararra finds show (Lamm 1928, pl. VI; pl. 119), and glass can be thinly shaped and carved in relief in ways very similar to rock crystal. This may be seen, for example, in the Buckley ewer (pl. 120), where the shape and decoration in relief is remarkably similar to the V&A rock crystal ewer (Stanley 2004, 94–95, pl. 107). But cut-relief glass, whether clear or colored, ceased to be produced in the Middle East some time during the eleventh century, being replaced by molded glass (pl. 124), a much more economical technique resulting in lower prices, one so successful that it has survived until today. Blowing the glass bubble, transparent or colored, into a previously carved mold (Lamm 1928–30, I: 58–59, II: pl. 131; pl. 122–b) allows for objects with pretty relief decorations, albeit rounded rather than sharp, to be produced on an industrial scale.

The notion of equivalence between rock crystal and glass as symbolically charged substances can also be supported by reference to records of early lamps in rock crystal. One example is the Qulayla, the lamp that originally hung in the mihrab of the Great Mosque of Damascus and was taken to Baghdad as the order of the Abbasid caliph al-Amin r. 809–13); the son of Harun al-Rashid, who is described by al-Ghazalli (1881–83, II: 284; Shalem 1994, 2) as a lover of rock crystal (hams yathribin al-hillârin). Ibn Jiba'îr (1149–1217) describes the Qulayla as "a lamp that seems to be of hollow crystal, and like a large drinking vessel" (Ibn Jiba'îr 1953, 284). It has also been suggested that the splendid Fatimid vessel carved in relief in the Hermitage (pl. 123) was originally a lamp (Lamm 1928–30, I: 1, 199–200; II: pl. 68–9; Shalem 1994, 1, fig. 1; Seipel 1998, 135–37, cat. 109), and similarly the big vase in the treasury of St. Mark (pls. 124–25).
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When seen without its mount (pl. 126), one can see that this was most probably its original function: it would have been attached to the ceiling through wires fixed around
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Ibn al-Haytham (1969, II 336) states: “When the first body is very transparent and the
second has weak transparency and a strong color, sight will perceive the second
and fail to sense the first because of its excessive transparency,” and it is interesting to
relate this passage to the lamp in St. Mark’s in its European guise, with a silver-gilt
mount and precious stones at the top and bottom, added by Venetian goldsmiths in
the thirteenth century. As Ibn al-Haytham predicted, the mount is the first thing one
perceives, rather than the lighter transparent object. But at the same time the mount
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As for its original function, one can only imagine the wonderful effect that
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No evidence has yet come to light suggesting that a state monopoly was
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Ibn al-Haytham (1869, 1: 339) states: “When the first body is very transparent and the second has weak transparency and a strong color, light will perceive the second and fail to sense the first because of its excessive transparency,” and it is interesting to relate this passage to the lamp in St. Mark’s in its European guise, with a silver-gilt mount and precious stones at the top and bottom, added by Venetian goldsmiths in the thirteenth century. As Ibn al-Haytham predicted, the mount is the first thing one perceives, rather than the lighter transparent object. But at the same time the mount has the opposite effect of actually “staging” the object and in this way emphasizing its

lightness and transparency, thus highlighting the effect already attained by the decision—a stroke of genius—to leave uncarved the middle area between the high-relief decoration of the upper and lower parts.

As for its original function, one can only imagine the wonderful effect that a light inside might have had, with a wick suspended on oil, in the way that it is reflected through the high relief as well as passing directly through the wall of the lamp. Yet there is no reference to any such effect in Ibn Jarays’ pious description of the Qalayla lamp, and the fact that, to judge by al-Maqrizi, the Fatimids might have been hugely fond of rock crystal hardly justifies making an explicit connection between its light properties and the religious sphere, and, more particularly, endowing it with a specific symbolic meaning such that, within the context of Isma’ili thought, it could be considered a “divine” substance (Makariou 2006, 240).

No evidence has yet come to light suggesting that a state monopoly was imposed upon rock crystal. It was carved in the Cairo bazaar, pointing to an industry wider than the court. Many of the surviving pieces are utilitarian, as the Geniza documents testify, mentioning small bottles or flasks as perfume or make-up containers, part of the...
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This is not to say that the lamp could not have been read symbolically. The question, rather, is whether the metaphorical connection with light was programmatic or endemic, a particular facet of Isma'ili thought involving rock crystal that was widely known and accepted in Fatimid society. It would, no doubt, be unreasonable to expect a scientific text such as that of Ibn al-Haytham to deal with light symbolically, but the fact remains that the assertions of Ibn Hani, the Fatimid panegyrist mentioned earlier, are surrounded by a general silence that makes it virtually impossible to reconstruct the "period gaze."

One can, though, consider the question of function: what were the rock crystal ewers used for? Were they on the caliph's table, filled with red wine, or maybe Sicilian tarocco orange juice? Or might water have been more appropriate? As a clear substance it would allow full play to the aesthetic qualities of the vessel, a property recognized by...
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This is not to say that the lamp could not have been read symbolically. The question, rather, is whether the metaphorical connection with light was programmatic or endemic, a particular facet of Isma’ili thought involving rock crystal that was widely known and accepted in Fatimid society. It would, no doubt, be reasonable to expect a scientific text such as that of Ibn al-Haytham to deal with light symbolism, but the fact remains that the assertion of Ibn Haitham, the Fatimid panegyrist mentioned earlier, is surrounded by a general silence that makes it virtually impossible to reconstruct the "period gone."

One can, though, consider the question of function: what were the rock crystal ewers used for? Were they on the caliph's table, filled with red wine, or maybe Sicilian tarocco orange juice? Or might water have been more appropriate? As a clear substance it would allow full play to the aesthetic qualities of the vessel, a property recognized by...
Ibn Haytham when he says: "[For consider] perfectly crafted transparent objects [made of glass or crystal] which . . . have been provided with beautiful designs and sculpted figures, and let them be filled with a strong- or dark-colored beverage . . . Sight will . . . not be aware of their beautiful features . . . For, being extremely transparent, their designs will not be visible, or will not appear as they really are." (Ibn al-Haytham 1989, I: 339). This passage may suggest that the beautifully carved rock crystal ewers were not used for a colored beverage like red wine. Water, instead, was regarded as one of the two elements of which rock crystal was compounded, as we have seen. It would thus have a symbolic association with the material of its container, and as a clear, transparent fluid it would have helped the sparkling play of light on the crystalline structure and select decoration to achieve its full aesthetic effect.

Notes
1 This is one of the pieces examined with these techniques at the V&A as part of a recent project entitled Line and Light that I am coordinating with various institutions, see also the essay by Marion Rollin-Dewar, Glashouse Hubbard, and James Stevenson. I am also grateful to the photography and for granting permission to reproduce the images.
2 Thanks are due to Ben Gastell, also part of the Line and Light project, who has done work with us and has demonstrated the procedure in his workshop. I am also grateful to permission to reproduce images of his work and of him carving a piece of rock crystal.
3 Analogous distinctions are also found in medieval Europe: the 1284 rapole (statute) of a ship's cargo of rock crystal carvings in Venice indicates the existence of two well-defined specialist groups, which deals with big pieces, and Kerr mina, which is about stylistic analysis.
4 In fact, the carving of rock crystal in India predates the advent of Islam, as it had been used for objects in Hindu and Buddhist contexts (Haidar 2011, 357).
5 It has been suggested that the rock crystal handle is a medieval piece, refashioned as a head of Mary magdalen according to Ottoman taste (Keramoff 2011, 210, cat. 12, Fig. 140).
6 It is intriguing to note a more specific reference to rock crystal in this context by (1633, Book 12, Ch. 10, 367–68). Referring to the authority of San Bernardo, he states a crystal is a symbol of the ideal man as well as of a virgin who, like the lapis bowl of the Virgin, is pure inside and outside. The sun's rays, passing through a piece of rock crystal, barn on the other side that is not pure, but the purity of the virginal uterus of Mary remains even when penetrated by the ray of the divine word.
7 Another participant in the Line and Light project is Stéphane Pradiere, whose archaological excavations have led to the recent discovery in Mavot, a small island of the Corinth pelagon in the western Indian Ocean, of blocks of rock crystals of great transparency in parnac, datable by archaeological stratigraphy between the ninth and the twelfth centuries (Pradiere 2013). Stéphane's discovery is in accord with al-Biruni's claim that the best rock crystal comes from the "isles of Zanj." Further research into the area of production include Connors, archeol., Madagascan, and the Néacan count may change our perception of routes and of the worked of rock crystal imports. This work in progress will include petrological analysis that will hopefully help us locate the origins of the rock crystal from which the vessels were carved.

Facets of Light
Ibn Haytham when he says: "[For consider] perfectly crafted transparent objects [made of glass or crystal] which ... have been provided with beautiful designs and sculpted figures, and let them be filled with a strong- or dark-colored beverage ... Sight will ... not be aware of their beautiful features ... For, being extremely transparent, their designs will not be visible, or will not appear as they really are." (Ibn al-Haytham 1969, I: 139). This passage may suggest that the beautifully carved rock crystal ewers were not used for a colored beverage like red wine. Water, instead, was regarded as one of the two elements of which rock crystal was compounded, as we have seen. It would thus have a symbolic association with the material of its container, and as a clear, transparent fluid it would have helped the sparkling play of light on the crystalline structure and relief decoration to achieve its full aesthetic effect.

Notes

1. This is one of the pieces examined with these techniques at the V&A as part of a new rock crystal project entitled Line and Light that I am coordinating with various institutions. Thanks are due here to Mariam Rossen-Owen, Charlotte Hardman, and James Stevenson for their contribution to the photography and for granting permission to reproduce the images.

2. Thanks are due to Ben Gaskell, also part of the Line and Light project, who has discussed this with me and has demonstrated the procedure in his workshops. I am also grateful to Ben for permission to reproduce images of his tools and of him carving a piece of rock crystal.

3. Analogous distinctions are also found in medieval Europe: the 1284 royal (cabinet) of the guild of rock crystal carvers in Venice indicates the existence of two well-defined specialties: Parte grande, which deals with big pieces, and Parte minore, which is about glyptic art.

4. In fact, the carving of rock crystal in India predates the advent of Islam, as it had long been used for objects in Hindu and Buddhist contexts (Haidar 2011, 307).

5. It has been suggested that the rock crystal handle is a medieval piece, refurbished with gems according to Ottoman taste (Komaroff 2011, 210, fig. 12, fig. 140).

6. It is intriguing to note a more specific reference to rock crystal in this context by Picinelli (1653, Book 12, Ch. 10, 301–62). Referring to the authority of San Bernardino, he states that rock crystal is a symbol of the ideal man as well as of a virgin who, like the limpid bowl of crystal, is pure inside and outside. The sun’s rays, passing through a piece of rock crystal, burn everything on the other side that is not pure, but the purity of the virgin’s uterus of Mary remained intact, even when penetrated by the ray of the divine word.

7. Another participant in the Line and Light project is Siphano Prodinos, whose archaological excavations have led to the recent discovery in Mayotte, a small island of the Comoros archipelago in the western Indian Ocean, of blocks of rock crystals of great transparency and transparency, datable by archaeological stratigraphy between the ninth and the twelfth centuries (see Prodinos 2011). Siphano’s discovery is in accord with al-Biruni’s claims that the best rock crystal comes from the “isles of Zanz.” Further research into the area of production including the Comoros archipelago, Madagascar, and the African coast may change our perception of the trade routes and of the control of rock crystal imports. This work in progress will include petrographic analyses that will hopefully help locate the origins of the rock crystal from which the Fatimid vessels were carved.
God Is the Light of the Heavens and the Earth

LIGHT IN ISLAMIC ART AND CULTURE

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