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# *The Diffusion of Rock Crystal Carving Techniques in the Fāṭimid Mediterranean*

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The art of carving rock crystal was unknown in Europe from the fall of Rome until the thirteenth century. Theophilus Presbyter, who wrote in Cologne in *circa* 1125, knew how, using abrasive sand and abrasive stones, rock crystal gems could be sawn (*secare*), ground (*limare*) into shape and polished (*polire*), but he believed that in order to carve (*sculpere*) the stone it had first to be heated in the cardiac cavity of a newly slaughtered goat.<sup>1</sup>

The earliest evidence that rock crystal vessels were being carved in Europe comes from legislation governing the guild of rock crystal workers and lapidaries — *des Cristalliers et des Perriers de pierres natureus* — issued by Étienne Boileau, one of the first known provosts of Paris, in 1268.<sup>2</sup> The earliest carved rock crystal objects attributed to Paris are given the same date.<sup>3</sup> At about the same time, documents first refer to a *scola et artes cristellariorum* in Venice,<sup>4</sup> while the first rock crystal vessels to be attributed to Venetian craftsmen are dated to the fourteenth century.<sup>5</sup>

The small group of gemstones and other objects produced for the Carolingian court in the ninth century, such as the Lothair Crystal in the British Museum, is the one securely attested exception,<sup>6</sup> to which we shall soon return. Two further *possible* exceptions are the European outposts of Islam in the Iberian Peninsula and Sicily where local traditions of carving rock crystal may — or may not — have developed. We shall discuss Sicily at some length,<sup>7</sup> but discussion of the putative rock crystal production of al-Andalus must await another occasion.

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<sup>1</sup> Theophilus Presbyter, *De Diversis Artibus: The Various Arts*, ed. and trans. Charles R. Dodwell, London etc.: Thomas Nelson and Sons Ltd, 1961, pp. 168–171.

<sup>2</sup> Étienne Boileau (1200?–1271), *Le livre des métiers*, ed. René de Lespinasse and François Bonnardot, Paris: Imprimerie nationale, 1886, Part 1, Title XXX, pp. 61–63.

<sup>3</sup> E.g. The Cloisters' Saltcellar, New York, Metropolitan Museum of Art, Acc. no. 1983.434. Charles T. Little and Timothy Husband, *Europe in the Middle Ages*, New York: Metropolitan Museum of Art, 1987, p. 92.

<sup>4</sup> H.R. Hahnloser, "'Scola et artes cristellariorum de Veneciis'", 1284–1319. *Opus venetum ad filium*', in *Venezia e l'Europa. Atti del XVIII Congresso Internazionale di Storia dell'Arte. Venezia 12–18 settembre 1955*, Venice: Arte veneta, 1956, pp. 157–165.

<sup>5</sup> E.g. the bronze and rock crystal reliquary cross in Santa Croce, Florence, signed by the Venetian bronze-smith Bertuccio and dated 1300: Luisa Marcucci, 'Per gli "armarj" della sacrestia di Santa Croce', *Mitteilungen des Kunsthistorischen Institutes in Florenz*, 9, 1960, pp. 141–158, at p. 142 and fig. 6.

<sup>6</sup> Geneva Kornbluth, *Engraved Gems of the Carolingian Empire*, University Park (PA): Pennsylvania State University Press, 1995.

<sup>7</sup> Avinoam Shalem, 'The rock crystal lionhead in the Badisches Landesmuseum in Karlsruhe', in Marianne Barrucand (ed.), *L'Egypte fatimide: son art et son histoire. Actes du colloque organisé à Paris les 28, 29 et 30 mai 1998*, Paris: Presses de la Université de Paris-Sorbonne, 1999, pp. 359–366. See also the works by Rudolf Distelburger (cited in note 23 below), who seems to assume that the putative rock crystal industry of the Norman Sicily was a continuation of a tradition established under Muslim rule; he offers no evidence to support this assumption.

The many rock crystal objects imported from Byzantium and the Islamic world before 1250 attest to the demand by European consumers.<sup>8</sup> Both written sources, such as Theophilus Presbyter, and the ubiquitous use of plain polished rock crystal gems in early medieval regalia, sacred objects and jewellery, suggest that sources of raw rock crystal in the European Alps were regularly exploited. It follows that the only reason why European craftsmen did not carve rock crystal was because they did not know how to do so.

From the Islamic world, literary sources report that raw rock crystal was imported into Basra and Cairo — two principal centres of production in the late tenth and eleventh centuries — from Western Arabia and the Hijaz, the islands of the Indian Ocean (Madagascar, the Maldives and Sri Lanka), the Maghrib specifically Morocco, Central Asia, Armenia, China, and 'the Lands of the Franks'. They also describe other centres of production in Ghaznavid Afghanistan and Marīnid Morocco that used local sources of rock crystal.<sup>9</sup> We ourselves have not yet been able to establish the provenance of the rock crystal used to make complete vessels.<sup>10</sup> Archaeology has so far yielded little evidence of trade or production of rock crystal. The small numbers of rock crystal beads and bead-wasters, and minute fragments of waste from bead production, found in

<sup>8</sup> A nearly complete list is given by Avinoam Shalem, *Islam Christianized: Islamic portable objects in the medieval church treasuries of the Latin West*, Frankfurt am Main: Peter Lang, 1996, pp. 177–226.

<sup>9</sup> Muḥammad ibn Aḥmad al-Būrīnī (d. post 1050, work composed 1040–1048), *al-Jamāhir fī al-jawāhir*, ed. Yūsuf al-Hādī, Tehran: Sharikat al-Nashr al-‘Ilmī wa-al-Thaqāfī, 1995, pp. 295–296; trans. Paul Kahle, 'Bergkristall, Glass und Glasflüsse nach dem Steinbuch von el-Būrīnī', *Zeitschrift der Morgenländischen Gesellschaft*, n.s. 90, 1936, pp. 322–356 at pp. 332–333 (problematic Eng. trans., Hakim Mohammad Said, *The Book Most Comprehensive in Knowledge on Precious Stones*, New Delhi: Adam Publishers, 2007, pp. 159–160): imported from the *jazā'ir al-Zanj* ('islands of al-Zanj', i.e. Madagascar) *wa-l-Dībajāt* (the Maldives) to Baṣra; vessels from Kashmīr (inferior quality and workmanship); found in Wakhān and Badakhshān (in Afghanistan on the border with Turkmenistan) but not exported; according to al-Kindī (d. circa 866, whose manual *Fī-l-jawāhir wa-l-ashbāh* is now lost), the best quality — *al-bilawr al-ā-rabī* — comes from the Arabian desert, and a less transparent variety from Sarandīb (Sri Lanka); there is a crystal mine on the frontiers of Armenia and Badlīs (Bitlis, East Turkey).

Shelomo D. Goitein, *A Mediterranean society: the Jewish communities of the Arab world as portrayed in the documents of the Cairo Geniza*, 6 vols, Berkeley: University of California Press, 1967–1993: vol. 1, pp. 268 and 467 note 11, rock crystal vessels imported from Fātimid Egypt to Zīrid Ifrīqiya (early 11th cent.); vol. 4, pp. 223, 224, 319, 322, 327, 343, 430, 467, general references; pp. 223–224, 430 note 539, rock crystal kohl-jars imported to Egypt from India or Yemen in the mid 1150s; (see also idem and Mordechai A. Friedman, *India traders of the middle ages: Documents from the Cairo Geniza: India Book, Part One*, Leiden: Brill, 2006, pp. 783–784 and note 25).

Naṣīr-i Khusrāw (writing of the year 1048), *Safarnāma. Sefer Nameh: Relation du voyage de Nassiri Khosrau en Syrie, en Palestine, en Égypte, en Arabie et en Perse*, ed. and trans. Charles H. Shefer, Publications de l'École des langues orientales vivantes, ser. 2, vol. 1, Paris: Ernest Leroux, 1881, pp. 149 (Fr. tr.)/51 (Pers.); *Nāṣer-e Khosraw's Book of Travels*, trans. Wheeler M. Thakston, Albany (NY): Bibliotheca Persica, 1986, p.53: in the Suq al-Qanādīl (Lamp Market) he saw fine carved rock crystal objects made of crystal from the Maghrib, and heard the crystal found near the Baḥr al-Qulzum (Red Sea) was still more beautiful and more transparent.

Aḥmad b. Yūsuf al-Tīfāshī (d. 1253), *Azhār al-afkār fī jawāhir al-ahjār*, ed. Muḥammad Yūsuf Ḥasan and Maḥmūd Basyūnī Khafājī, Cairo: al-Hay'ah al-Miṣrīyah al-‘Āmmah lil-Kitāb, 1977, pp. 201, 202; *Arab roots of gemology. Ahmad ibn Yusuf Al Tifaschi's Best Thoughts on the Best of Stones*, trans. and commentary Samar Najm Abul Huda, Lanham (MD) and London: Scarecrow Press, 1998, p. 166, 167: the best rock crystal formed in the Arabian Desert (*Barrīyat al-‘Arab*) in the Hijāz; an inferior variety comes from China (*al-Ṣīn*); good quality rock crystal comes from 'the lands of the Franks' (*Bilād al-Ifranja*); yellowish rock crystal, called 'glassy' (*al-zujājīya*), comes from mines near Armenia; new mines had recently been discovered in al-Maghrib al-Aqṣā, near Marrakesh, which produce clear but cracked rock crystal; he has heard that thirteen days march on the road from Ghazna are two mountains of pure rock crystal, used by the Ghaznavid rulers and the people of Kashgar.

Shams al-Dīn Abū ‘Abd Allāh Muḥammad b. Ibrāhīm b. Sā‘id, known as Ibn al-Akfānī (d. 1348), *Kitāb nukhab al-dhakhā‘ir fī ahwāl al-jawāhir*, in *Al-Mashriq: majalla Kāthūlīkīya sharqīya tabḥathu fī al-‘ilm wa-al-adab wa-al-fann / Al-Mashriq: Revue catholique orientale mensuelle: Sciences — Lettres — Arts* (Université St Joseph, Beirut) 11, 1908, pp. 751–765, at p. 762: *jazā'ir* (corr. from *khazā'in*) *al-Zanj*, Kashmīr, Badakhshān, Bitlis, Armenia, Ceylon, the lands of the Franks, and Morocco.

See also the only contemporary source (compiled 1250; revised 1276–1279) to suggest that rock crystal came directly from the African mainland: *Primer lapidario del rey Alfonso X el Sabio: Edición facsímil del códice h.I.15 de la Biblioteca de San Lorenzo el Real de El Escorial*, Serie Códices Artísticos, Número 5, Madrid: Editora Internacional de Libros Antiguos, Edilán, 1982: f. 59r: 'la piedra a que dicen en arábigo *bollar*, y en latín *crystal* ... hállanla en muchas partes, más la mejor de todas, es la que hallan en tierra de Etiopia'; *El Primer lapidario de Alfonso X el Sabio: Ms. h.I.15 de la Biblioteca de El Escorial*, ed. Maria Brey Mariño et al., Madrid, Edilán, 1982, pp. 114–115. It is striking that nothing in the *Lapidario* indicates that its compilers were familiar with the techniques required to carve rock crystal or other hard stones.

<sup>10</sup> Raman spectroscopy has been used successfully to identify inclusions in rock crystal artefacts and may offer a way forward: Margaret Sax, Jane M. Walsh, Ian C. Freestone, Andrew H. Rankin and Nigel D. Meeks, 'The origins of two purportedly pre-Columbian Mexican crystal skulls', *Journal of Archaeological Science* 35/10, 2008, pp. 2751–2760; M. Sachanbiński, R. Girulski, D. Bobak and B. Łydzba-Kopczyńska, 'Prehistoric rock crystal artefacts from Lower Silesia (Poland)', *Journal of Raman Spectroscopy* 39, 2008, pp. 1012–1017.

archaeological contexts at Kilwa, Manda, Shanga and other East African coastal sites do not justify claims that an international trade-route began far inland at Tsavo, Kitui, or even the Kerio Valley in the Central Rift, and terminated in the workshops of Başra and Cairo. It contradicts what is often claimed, no Arabic source reports that rock crystal came from mainland East Africa.<sup>11</sup> The raw rock crystal found on coastal sites is perhaps most likely to have been imported by sea from sources in the Indian Ocean; at the same periods, chlorite-schist vessels were imported from Madagascar,<sup>12</sup> and it has been suggested that the techniques used on the coast to manufacture rock crystal beads themselves originated in south India or Sri Lanka.<sup>13</sup>

The extreme hardness of rock crystal (Mohs scale 7.0), together with its homogenous crystalline structure, make it impossible to sculpt with the percussive tools — the hammer and point — used by the stonemason or sculptor. Instead, the crystal must be ground away using an abrasive, such as powdered corundum or diamond, mixed with a liquid lubricant such as oil or water. Different tools were used as vectors to carry the abrasive powder to the surface of the crystal: hand-held wires or metal saws to rough out the vessel; a *vertical* bow-drill driving a tubular drill to start hollowing out the vessel; and a *horizontal* bow-lathe driving first a succession of gouges to complete the interior cavity, and then a series of grinding disks, cutting wheels and drill bits to shape the exterior of the vessel and carve the decoration. For this last process, the carver held the vessel in his hands and presented its surface to the vector rotating on the horizontal lathe, applying the abrasive mixture that actually did the cutting. Only objects small enough to be constantly manipulated by the craftsman against the carving tool on the fixed bow-lathe can be produced by this technique.

The techniques of carving rock crystal could have been transferred from one centre of production to another only by craftsmen experienced in all aspects of the craft, not by descriptive accounts, still less by the vessels themselves. Nonetheless, it has been proposed that both Carolingian glyptic, and the putative rock crystal production of Norman Sicily, developed not by the migration of expert lapidaries but rather by the adaptation of techniques from different

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<sup>11</sup> There is a general tendency to exaggerate the importance of the archaeological finds of rock crystal in East Africa; see, for example James De Vere Allen, *Swahili Origins: Swahili Culture and the Shungwaya Phenomenon*, London: Currey, 1993, pp. 24–25, 26, 30, 31, 55, 59, 186; Mark C. Horton and John Middleton, *The Swahili: the social landscape of a mercantile society*, Oxford: Blackwell, 2000, pp. 79, 80, 22 notes 21–23. (For the manner in which these rock crystal finds have fueled the debate about the pastoralist origins for the Swahili, see Randall L. Pouwels, 'East African coastal history', *The Journal of African History*, 40, 1999, pp. 285–296 at p. 290). The meagre evidence may be summarised as follows. H. Neville Chittick, *Kilwa: An Islamic Trading City on the East African Coast*, 2 vols., Nairobi: British Institute in Eastern Africa, 1974, vol. 1, pp. 474–475, 485: finds of rock crystal beads — Period I (9th century), none; Period II (late 12th to late 13th century), none; Period IIIa (late 13th century– c. 1400), 1; Period IIIb (c. 1400 — c. 1500), 2; Period IIIb–IV, 2; Period IV (16th–17th century), 8; Unstratified, 8; in every period, rock crystal beads comprised far less than 1% of total beads. Idem, *Manda: excavations at an island port on the Kenya coast*, Nairobi: British Institute in Eastern Africa, 1984, pp. 184, 186–187: of the 15 beads of stone and semi-precious stone, crystal-quartz was 'most represented' (approx. 6 beads?); they occur in all three periods, but most in Period II (mid 11th — late 13th century). Mark Horton, *Shanga: The Archaeology of a Muslim Trading Community on the Coast of East Africa*, British Institute in Eastern Africa, Monograph Series 14: London, 1996, pp. 324–325, 332, 333 fig. 254, 437: approximately 50 rock crystal beads or bead-wasters, no more than 5 from any context, all but one from contexts dated after Phase 9 (c. 960), with the greatest number in Phase 16 (c. 1250); another 11 rock crystal objects or lumps of waste were found, the largest being a 'worked core' measuring 20mm x 21mm x 10mm. Rock crystal is also reported at Malindi (James S. Kirkman, *The Arab city of Gedi. Excavations at the Great Mosque: Architecture and finds*, Oxford: Oxford University Press, 1954, p. 134: 'An unpierced crystal pendant was found on the beach at Malindi') and Gedi (no details yet published). The most tantalising report comes from Tumbatu Island off Zanzibar where 'Le trésor de Gomani était composé de nombreux blocs de cristal de roche. Il fut découvert en construisant une nouvelle mosquée sur un site daté des XIIe–XIIIe siècles' (Stéphane Pradines, *Gedi: une cité portuaire swahilie: Islam médiéval en Afrique orientale*, Publications de l'Institut français d'archéologie orientale du Caire, 1017; Fouilles de l'Institut français d'archéologie orientale du Caire, 60, Cairo, 2010, p. 14, and note 78), citing an unpublished report: Catherine Clark and Mark Horton, *The Zanzibar Archaeological Survey 1984–5*, Zanzibar. (Since delivering this paper in April 2013, possible confirmation of the importance of Madagascar as a source of rock crystal has come from Dr Stéphane Pradines's excavations at Dembeni on the island of Mayotte in the French Comoros, which he believes to have been an entrepôt preparing rock crystal from Madagascar for shipping on to Egypt and Iraq: Stéphane Pradines, 'African Rock Crystal: Production and Trade between the 9th–12th centuries', Research Seminar in Islamic Art, Department of the History of Art & Archaeology, SOAS, University of London, Thursday 16th January 2014.)

<sup>12</sup> Chittick, *Kilwa*, 1974, vol. 2, pp. 412–413; Horton, *Shanga*, 1996, p. 354.

<sup>13</sup> Horton, *Shanga*, 1996, p. 332, citing Leonard. Gorelick and A. John Gwinnett, 'Diamonds from India to Rome and beyond', *American Journal of Archaeology* 92, 1988, p.p. 547–552.

technologies to carving rock crystal.

Genevra Kornbluth insists that the decoration of the small group of Carolingian gemstones and other objects, such as the Lothair Crystal in the British Museum, only exhibit smooth continuous curves, and never the segmented curves characteristic of Byzantine and Islamic carving — that is, curves made up of short lengths of intersecting straight lines.<sup>14</sup> She believes that the smooth curves of Carolingian engraving must have been made by a cutting disk with rounded sides or by a ball-shaped drill. She hypothesizes that such rounded tools were used by the engravers who made the dies for the high quality portrait-issue coins of the Carolingian *renovatio imperii*, and that these techniques were adapted to engraving hard-stone. She therefore concluded that the techniques used to engrave Carolingian hard-stones were not imported by migrant craftsmen from the East.

This hypothesis fails on all levels. Carolingian dies — like all ancient and medieval dies — were engraved with burins and punches, not wheel-cut. Cutting disks with rounded sides do not make continuous curves, but only segmented curves. And, most importantly, the curves on Carolingian crystals are segmented curves, exactly like those made by Byzantine or Islamic carvers. Three lessons are to be drawn from this example.

First, Carolingian hard-stone objects were carved using techniques originally imported to the Rhineland by migrant craftsmen from the East, presumably from Byzantium. Second, the style of the Carolingian decoration is local not Byzantine, demonstrating that style need not indicate the origin of the technique of production. And, third, conclusions based upon outdated analyses — such as Kornbluth's reliance in 1995 upon relatively low magnification — may need to be reassessed in the light of more up-to-date archaeometrical methods.

Turning to Sicily, there is no conclusive evidence that any rock crystal object was carved on the island under Muslim or Norman rule. The hypothesis seems to rest upon the presence in Sicily of two objects — the sword-pommel in Enna,<sup>15</sup> and the cylindrical flask in Agrigento<sup>16</sup> — that are decorated with the same simplified version of a Fāṭimid half-palmette that is used to represent the whiskers on the Karlsruhe lionhead.<sup>17</sup> That lionhead is compared to lionheads in other media from Norman Sicily: on the Mantle of Roger II,<sup>18</sup> in the painted ceilings of the Cappella Palatina,<sup>19</sup> on an anepigraphic follis attributed to King William II,<sup>20</sup> and — most importantly — on the porphyry sarcophagus carved in Palermo for King Roger II before 1145, now the Tomb of Frederick II.<sup>21</sup> Because porphyry is approximately as hard as rock crystal (Mohs scale 6–7), the hypothesis assumes that the existence in Palermo of a workshop of porphyry sculptors strengthens the case that rock crystal, too, was carved in Norman Sicily as if the technology used to sculpt porphyry could have been adapted to carve rock crystal.

Again, this cannot be so. Although porphyry is almost as hard as rock crystal, its crystalline structure is fundamentally different. While a block of raw rock crystal is a single

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<sup>14</sup> Kornbluth, *Engraved Gems*, 1995, pp. 11–16.

<sup>15</sup> Claudia Guastella, 'Frammenti di Elsa', in Maria Andaloro (ed.), *Nobiles Officinae: Perle, filigrane e trame di seta dal Palazzo Reale di Palermo*, 2 vols, Catania: Maimone Editore, 2006, vol. 1, pp. 317–318 (Eng. 593–594).

<sup>16</sup> Idem, 'Flacone reliquario' in Andaloro (ed.), *Nobiles Officinae*, 2006, vol. 1, pp. 314–316 (Eng. 692–693).

<sup>17</sup> Shalem, 'The rock crystal lionhead', 1999.

<sup>18</sup> Rotraud Bauer, 'Manto di Ruggero II', in Andaloro (ed.), *Nobiles Officinae*, 2006, vol. 1, pp. 44–49 (Eng. 576–578).

<sup>19</sup> Jeremy Johns, 'Le pitture del soffitto della Cappella Palatina', in Beat Brenk (ed.), *La Cappella Palatina a Palermo*, *Mirabilia Italiae* 17, 4 vols, Modena: Franco Cosimo Panini Editore, 2010, *Schede*, scheda 374, pp. 492–494 and the figures referenced there.

<sup>20</sup> Lucia Travaini, *La monetazione nell'Italia normanna*, Istituto storico italiano per il medio evo, *Nuovi studi storici* 28, Roma: Pliniana, 1995, pp. 318–321.

<sup>21</sup> Josef Deér, *The Dynastic Porphyry Tombs of the Norman Period in Sicily*, *Dumbarton Oaks Studies* 5, Cambridge (Mass.): Harvard University Press, 1959, especially pp. 46–69. Maria Andaloro and Rosalia Varoli-Piazza (eds.), *Il Sarcofago dell'Imperatore. Studi, ricerche e indagini sulla tomba di Federico II nella Cattedrale di Palermo, 1994–1999*, 3 vols, Palermo: Regione Siciliana, Centro regionale per il restauro, Officine Grafiche Riunite, 2003. Francesco Gandolfo, 'Il porfido ('Porphyry')', in Andaloro (ed.), *Nobiles Officinae*, 2006, vol. 2, 201–215 (Eng. 417–423).

homogenous crystal, porphyry is composed of many large-grained crystals dispersed in a fine-grained matrix, and can be sculpted using the percussive techniques of hammer and point. While saws and abrasive powder were used to shape the Sicilian sarcophagi, tubular drills and abrasive powder were used to hollow out their troughs, and the high polish of their surfaces was achieved by the use of abrasive stones and powders, only these techniques were shared with rock crystal carving. The sarcophagi and their supports are far too big and heavy to have been held in the hands of the carver and presented to the grinding-wheel or cutting-disk driven by a horizontal bow-lathe. The plastic decoration on the sarcophagi — such as the lionheads — was made with the traditional tools of the sculptor — the hammer and point, and the drill — and not by the techniques used to carve rock crystal. (Incidentally, the techniques of sculpting porphyry were imported to Norman Palermo, presumably by craftsmen from Rome.<sup>22</sup>)

If rock crystal was indeed carved in Norman Sicily then the technology must have been imported by expert craftsmen, probably from Fāṭimid Egypt. This is certainly possible: the Norman kings imported a wide range of craftsmen and their techniques — mosaicists and textile workers from Byzantium; masons and sculptors from France and mainland Italy; scribes and painters from Fāṭimid Egypt — to achieve their multicultural royal art and architecture. But there is no conclusive evidence that they did import rock crystal carvers.

The present tendency to attribute whole classes of unattributed artefacts to Norman Sicily — including faceted rock crystal vessels without decoration,<sup>23</sup> and the so-called "Hedwig Beakers"<sup>24</sup> — rests heavily upon the false assumption that the techniques of sculpting porphyry could have been adapted to carving rock crystal and, thence, to wheel-cutting glass. Our growing database of medieval Islamic rock crystal carving may one day produce evidence to support the hypothesis of rock crystal production in Norman Sicily, but it has not done so yet. Much of the argument for the unity of Mediterranean culture in the tenth to twelfth centuries rests upon art-historical comparisons and stylistic similarities; too little attention is paid to the technological divides that, especially before the thirteenth century, separated the Islamic from the Christian Mediterranean, and — *a fortiori* — from sub-Saharan Africa.

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<sup>22</sup> Deér, *Dynastic Porphyry Tombs*, 1959, pp. 136—165.

<sup>23</sup> Rudolf Distelberger, "Die Gefässe aus Bergkristall," in Wilfried Seipel (ed.), *Nobiles Officinae: Die königlichen Hofwerkstätten zu Palermo zur Zeit der Normannen und Staufer im 12. und 13. Jahrhundert*, Skira: Milan, 2004, pp. 109-113; idem, 'I cristalli di rocca (Rock crystal)', in Maria Andaloro (ed.), *Nobiles Officinae: Perle, filigrane e trame di seta dal Palazzo Reale di Palermo*, 2 vols, Giuseppe Maimone Editore: Catania, 2006. vol. 2, pp. 194–199 (Eng., 414–416).

<sup>24</sup> Rosemarie Lierke, *Die Hedwigsbecher – das normannisch-sizilische Erbe der staufischen Kaiser*, F. Rutzen Verlag: Mainz-Ruhpolding, 2005; Jens Kröger, 'The Hedwig Beakers: Medieval European Glass Vessels Made in Sicily around 1200', in Annette Hagedorn (ed.), *The Phenomenon of "Foreign" in Oriental Art*, Wiesbaden: Reichert, 2006, pp. 27-46; Timothy B. Husband, 'The Asseburg-Hedwig Glass Re-emerges', in Evelyn Staudinger Lane, Elizabeth Carson Pastan, and Ellen M. Shortell (eds.), *The Four Modes of Seeing: Approaches to Medieval Imagery in Honor of Madeline Harrison Caviness*, Ashgate: Burlington, Vt., 2009, pp. 44–62; David Whitehouse, 'Hedwig Beakers', Corning Museum of Glass Website, n.d. <<http://www.cmog.org/article/hedwig-beakers>>