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Notes

vessels from the late Roman[3] to Islamic[4] periods. However, none of the patterns on these vessels is identical to that on the mold. The originally proposed date is not very convincing because there seems to be no Syrian glass of that time with such a pattern. None of the Hama finds is related in any way to this pattern.[5] Therefore, the mold may have been made in the early Islamic period.

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3. E. Marianne Stern, *Roman, Byzantine, and Early Medieval Glass, 10 BCE–700 CE: Ernesto Wolf Collection*, Ostfildern-Ruit: Hatje Cantz, 2001, nos. 138 (bottle from Syria, fourth to fifth century), and 156 (bowl, late fourth to early fifth century).

4. *Glass from the Ancient World: The Ray Winfield Smith Collection*, Corning: The Corning Museum of Glass, 1957, cat. no. 466 (Islamic pitcher, about seventh to ninth century); Stefano Carboni, *Glass from Islamic Lands*, New York: Thames & Hudson, 2001, cat. nos. 53a and 62; Carboni and Whitehouse [note 1], cat. nos. 15 (Egypt, ninth to 10th century) and 26 (Western Asia, probably Iran, about 12th century).

5. P. J. Riis, *Hama: Fouilles et recherches, 1931–1938*, v. 4, no. 2, *Les Verreries et poteries médiévales*, Copenhagen: Fondation Carlsberg, 1957.

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A Hedwig Beaker Fragment from Brno (Czech Republic)

In 1999, during an excavation in connection with the restoration of the Jiří-Mahen Library in Brno, Czech Republic, a Hedwig beaker fragment was discovered. In the yard behind the library, the remains of several medieval wooden buildings, as well as waste deposits and wells, were excavated. One of these buildings is thought, on the basis of dendrochronological evidence, to have been built after 1235, and it was destroyed by fire about 1275. The beaker fragment, along with a Gothic key and a glazed stove tile fragment, was found in this building. The destruction of the building was dated by ceramic evidence. A brief history of Brno that includes information on possible early owners of Hedwig beakers has been published by Peter Kováčik and others.[1]

The almost colorless glass fragment (inv. no. 98/59-324-5) is housed in the Museum Města Brna. Figure 1 presents two views. The maximum dimension is 4.5 centimeters, and the thickness of the fragment varies from 0.18 to 0.4 centimeters because it was carved on a wheel. The glass contains a few bubbles, and there are traces of weathering on its outer surface.

The decoration consists of a heart-shaped palmette with a flat groove that divides its two branches. This palmette is not much different in form and size from that on the Hedwig beaker at Veste Coburg, Germany (Fig. 2, center). The Coburg palmette expands into two volutes at its edges, while the Brno fragment is without volutes.

Chemical Analysis

Table 1 presents the chemical compositions of the Brno fragment and five other Hedwig beakers, which were analyzed by microprobe. The differences are minimal except for silica and sodium, which are inversely correlated. The glass is low in aluminum and iron, indicating the use of rather pure quartz sand. Two types of soda-lime glasses were made in antiquity. One was produced from natron. It made use of trona ($Na_3H(CO_3)_2.2\,H_2O$), quartz, and lime. It usually contained less than 1% MgO and 1% K_2O. Workshops of the Roman era and the early medieval period in Europe employed this type of glass, importing trona from the evaporites of lakes in northern Egypt (Wadi Natrun). The other type, soda-ash glass, was produced from the ashes of halophytic plants that grow on beaches and in deserts. The soils in these areas impart higher levels of magnesium and potassium to the glass.

Acknowledgment. We thank Prof. Kurt Mengel for conducting the chemical analysis of the beaker fragment from Brno.

1. Peter Kováčik, David Merta, Marek Peška, and Rudolf Procházka, "Brünn- von der frühmittelalterlichen Agglomeration zur Residenzstadt des Spätmittelalters," in *Medieval Europe, Basel 2002, Center-Region-Periphery*, ed. Guido Helmig, Barbara Scholkmann, and Matthias Untermann, 3rd International Conference of Medieval and Later Archaeology, Basel, September 10–15, 2002, v. 2, section 4.5, pp. 248–255.

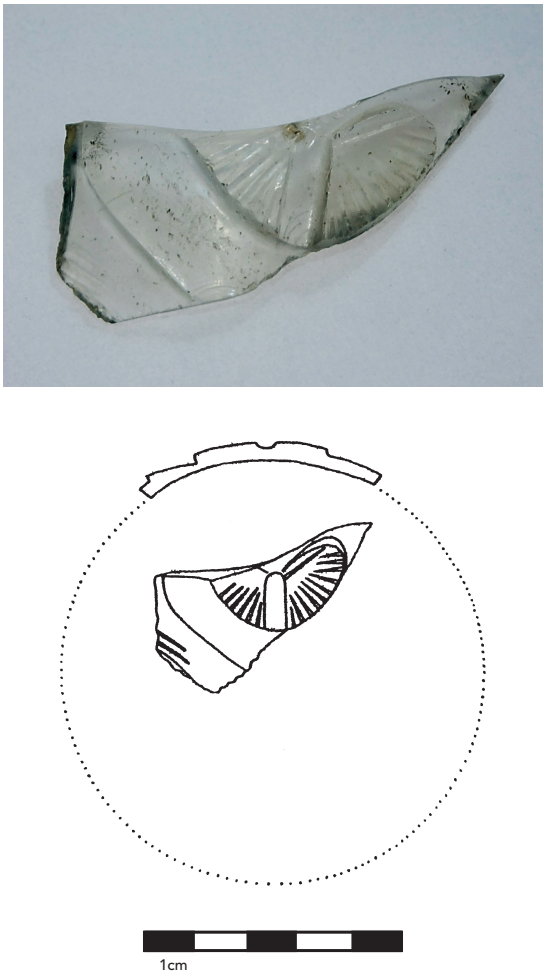

FIG. 1. *Photograph and drawing of Hedwig beaker fragment from Brno, including extrapolated beaker wall at level of palmette decoration. The diameter of the vessel at this level would have been about 7–8 centimeters.*

Because the production of soda-ash glass was restricted to glass factories in the Islamic world between 900 and 1250, the glass of the Hedwig beakers apparently came from this region. After 1250, Venice began to import halophytic plant ash, and European glass factories were able to make high-quality soda-ash glass. The Hedwig beakers are thought to have been produced in the early 13th century.

On the basis of the data reported in Table 1, we can compare the composition of the Hedwig beakers with that of glasses from different Islamic provinces. Low aluminum and iron concentrations

FIG. 2. *Hedwig beaker at Veste Coburg, Germany. H. 10.3 cm. (Photo courtesy of Kunstsammlungen Veste Coburg)*

as indicators of high-quality quartz sands are restricted to Hedwig beakers and to glass from the Levant. Most of the Islamic glass producers added MnO in amounts above 0.3% as a decolorizer to their melts, except in the case of the Hedwig beakers. MgO levels are markedly lower in Islamic glasses from the Levant (Caesarea, Tyre, and Banias) than in those made in Egypt, Persia, and Syria. But the quantity of MgO in Hedwig beakers is even lower than that found in the average Levantine glass. This element is apparently diagnostic in recognizing Hedwig beakers as products of Levantine glass manufacture, based on halophytic plant ash that is low in magnesium. The levels of CaO, Na_2O, K_2O, and P_2O_5 are almost identical in the various Islamic glasses shown in Table 1.

Recent excavations at Tyre have unearthed the remains of glasshouses with furnaces that produced large amounts of glass in the 10th and 11th centuries.[2] Documentary evidence has underscored

2. Fred Aldsworth and others, "Medieval Glassmaking at Tyre, Lebanon," *Journal of Glass Studies*, v. 44, 2002, pp. 49–66.

the high quality of the glass manufactured in the Levant between the 10th and 13th centuries.

Conclusions

Artistic glass vessels such as the Hedwig beakers require a long tradition of high-quality glassmaking and glass cutting. Such craftsmanship did not exist in Europe during the early 13th century, but it was evident in the Islamic countries.[3] Because low-magnesium soda-ash glass was made in the Levant, this is the likely area of production for the beakers. Crusaders may have carried these vessels to churches and to members of the nobility in central Europe.[4] In terms of its dimensions, decoration, and chemical composition, the Brno fragment is consistent with the two dozen known Hedwig beakers.

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TABLE 1

Soda-Ash Glass from Six Hedwig Beakers, 43 Glasses from the Levant, and 106 Glasses from Egypt, Persia, and Syria

	Hedwig Beaker *Brno (Czech Republic)*	*Hedwig Beaker* *Bommersheim (Germany)*	*Hedwig Beaker*[5] *London (U.K.)*	*Hedwig Beaker*[6] *Corning, New York (U.S.)*	*Hedwig Beaker* Wedepohl [note 3] *Göttingen (Germany)*	*Hedwig Beakers (2)* Wedepohl [note 3] *Hilpoltstein (Germany)*	*Hedwig Beakers (6)* *Average*	*Islamic Glasses, 10th–13th Centuries (43)*[7] *Levant Average*	*Islamic Glasses, 9th–13th Centuries (106)* Brill [note 6] *Egypt, Persia, and Syria Average*
SiO_2	73.2	69.7	69.3	67.7	69.6	67.8	69.6	68.4	66.5
TiO_2	0.07	0.1	0.10	0.1	0.1	0.09	0.09	0.11	0.16
Al_2O_3	1.12	1.32	1.50	1.24	1.57	1.10	1.31	1.35	2.06
Fe_2O_3	0.43	0.57	0.66	0.65	0.67	0.62	0.60	0.56	1.02
MnO	0.22	0.35	0.32	0.28	0.30	0.69	0.36	1.00	0.71
MgO	1.75	1.66	1.69	1.7	1.6	2.21	1.77	2.96	4.21
CaO	8.56	7.41	7.10	8.4	6.6	9.60	7.94	8.67	7.17
Na_2O	11.34	16.18	15.60	14.2	16.3	13.69	14.6	13.4	14.6
K_2O	2.65	2.89	2.68	3.3	3.1	2.85	2.91	2.27	2.74
P_2O_5	0.48	0.42	0.35	0.62	0.44	0.20	0.42	0.32	0.41
Cl	1.04	0.88	1.00			0.64	0.89	0.79	n.d.

3. Aldsworth and others [note 2]; Stefano Carboni and David Whitehouse, with contributions by Robert H. Brill and William Gudenrath, *Glass of the Sultans*, New York: The Metropolitan Museum of Art in association with The Corning Museum of Glass, Benaki Museum, and Yale University Press, 2001, pp. 160–161; Karl Hans Wedepohl, "Die Gruppe der Hedwigsbecher," *Nachrichten der Akademie der Wissenschaften, Göttingen, II Mathem.-Physik. Klasse*, v. 1, 2005, pp. 1–33.

4. Wedepohl [note 3].

5. Private communication from Ian C. Freestone.

6. Robert H. Brill, *Chemical Analyses of Early Glasses*, v. 1, *Catalog of Samples*, and v. 2, *Tables of Analyses*, Corning: The Corning Museum of Glass, 1999.

7. Ian C. Freestone, "Composition and Affinities of Glass from the Furnaces on the Island Site, Tyre," *Journal of Glass Studies*, v. 44, 2002, pp. 70, 71, and 75; Ian C. Freestone, Yael Gorin-Rosen, and Michael Hughes, "Primary Glass from Israel and the Production of Glass in Late Antiquity and the Early Islamic Period," in *La Route du verre: Ateliers primaires et secondaires du second millénaire av. J.-C. au Moyen Age*, ed. Marie-Dominique Nenna, Travaux de la Maison de l'Orient Méditerranéen, no. 33, Lyons: Maison de l'Orient Méditerranéen–Jean Pouilloux, 2000, pp. 77, 78, and 80.