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THIS ARTICLE discusses eight glass tiles from the priory of Saint-Sauveur in Burgundy. These dark squares, marbled with red and white glass inlays, are well preserved. They are located in various museums and collections. Six of these tiles were found by archaeological societies in the 19th and early 20th centuries. Two of them were later acquired by the Archaeological Museum of Dijon (Figs. 1 and 2), and the other four entered the collection of the Musée Rolin in Autun (Fig. 3). The remaining two tiles, which belong to the owner of the priory, Jacques Bacot (Figs. 4 and 5), were uncovered in the vicinity of the building during plumbing installations (Fig. 6).

The study of these objects was initiated by Christian Sapin in 1990.[1] At that time, they were considered to be of early medieval date, and they were subsequently published in the catalog of an exhibition at Paderborn.[2] Probably on that occasion, one of the tiles was analyzed by Karl Hans Wedepohl.[3] Although we have not been able to identify the specific tile or the analytical technique employed, we assume that it was one of the two tiles now in Dijon.

Provenance

The village of Saint-Sauveur is situated in the department of Côte-d'Or, Burgundy, about 30 kilometers from Dijon. The priory of Saint-Sauveur was established during the Carolingian period, because a charter dating to the year 883 states that it was founded under the name of "Alpha" and the patronage of the Savior.[4] This document also notes that King Louis the Pious (778–840) and his son Charles the Bald (823–877) made rich provision for the religious house.[5]

Although the initial appearance of the building is unknown, a report of 1636, written after a visit to the church, described "tiles of various colors and very antique."[6] In his "description of the duchy of Burgundy," published in 1775, Claude Courtépée (1721–1781) also mentioned the presence of glass tiles in the church of Saint-Sauveur. He dated the tiles to the 11th century and described them as made of painted glass.[7] So the tiles were present in the church by the 17th century.

The Tiles

Although glass inlays are known from the Hellenistic and Roman worlds,[8] glass tiles have

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Acknowledgments. We thank Jacques Bacot and the museums of Dijon and Autun for permitting us to conduct analyses of their glass tiles.

1. Christian Sapin, "Saint-Sauveur (Côte-d'Or)," in *Saint-Germain d'Auxerre: Intellectuels et artistes dans l'Europe carolingienne, IX^{e}–XI^{e} siècles*, [Auxerre]: [Musée d'Art et d'Histoire], 1990, pp. 224–225.
2. Christian Sapin, "Glasfliesen aus Saint-Sauveur," in *799: Kunst und Kultur der Karolingerzeit. Karl der Grosse und Papst Leo III in Paderborn*, Mainz: Zabern, 1999, pp. 564–565.
3. Uwe Lobbedey, Francesca Dell'Acqua, and Karl Hans Wedepohl, "Colored Glass Wall Tiles from Corvey (Germany): Carolingian or Romanesque?," *Journal of Glass Studies*, v. 43, 2001, pp. 89–105.
4. The exact date of the founding is still unknown.
5. Sapin [note 2], p. 565.
6. *Ibid.*
7. Claude Courtépée, *Description historique et topographique du duché de Bourgogne*, v. 2, Dijon, 1775, p. 445.
8. See Yael Gorin-Rosen, "Byzantine Gold Glass from Excavations in the Holy Land," *Journal of Glass Studies*, v. 57, 2015, pp. 97–119, esp. p. 113.

FIG. 1. *Tile from Saint-Sauveur in Dijon (Dijon 1).*

FIG. 2. *Tile from Saint-Sauveur in Dijon (Dijon 2).*

FIG. 3. *Tiles from Saint-Sauveur in Autun (Autun 1–4).*

not been frequently found in northwestern Europe, and we must look to Byzantine lands to find comparable pieces. The most attractive of these parallels are undoubtedly tiles of gold glass, among which one of the most famous examples is the panel from the Birds' Mosaic Mansion at Caesarea, dated from the late sixth to early seventh centuries.[9] Anastassios Antonaras has published triangular tiles from the seventh-century Church of Saint Demetrius in Thessaloniki. Some of those tiles are still in place on an arch. In the composition, next to the gold-glass pieces, are fragmentary, dark-colored square tiles made of glass and other square tiles made of stone with red trails.[10]

In the palatial eighth-century chapel of San Pietro in Corte in Salerno, Italy, the remains of decoration in opus sectile have been found. The decoration is made of marble, colored stone, and glass.[11] Closer to Burgundy, the apse wall of the Basilica of Sant'Ambrogio in Milan was equipped in the fourth or sixth century with figural opus sectile that was transferred to a new apse in the ninth century under the direction of Angilbert II, who served as the city's archbishop

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9. *Ibid.*, pp. 110–113.

10. Anastassios Antonaras, "Gold-Glass Tile Decoration in the St. Demetrios Basilica, Thessaloniki," *Annales de l'Association Internationale pour l'Histoire du Verre*, v. 18, Thessaloniki, 2009 (2012), pp. 301–306.

11. Alessandro Di Muro, *La cultura artistica della Langobardia minor nell'VIII secolo e la decorazione pavimentale e parietale della cappella palatina di Arechi II a Salerno*, Naples: Consorzio Beni Culturali Campania, 1996, pp. 30–31.

12. Carlo Bertelli, "S. Ambrogio da Angilberto II a Gotofredo," in *La citta del vescovo dai Carolingi al Barbarossa*, ed. Carlo Bertelli, Il millennio ambrosiano, v. 2, Milan: Electa, 1988, pp. 18 and 57.

FIG. 4. *Tile from Saint-Sauveur in the collection of Jacques Bacot (Bacot 1).*

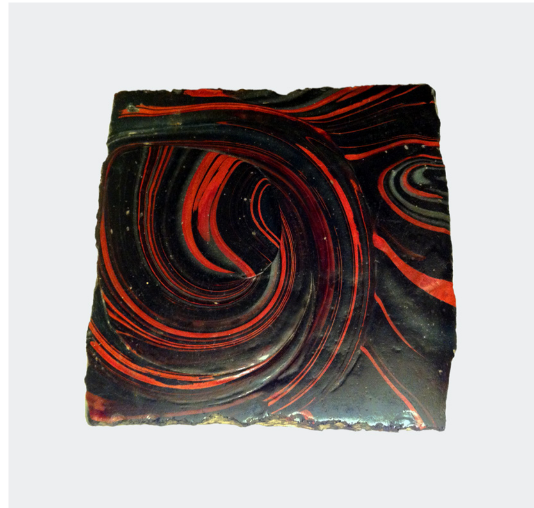

FIG. 5. *Tile from Saint-Sauveur in the collection of Jacques Bacot (Bacot 2).*

FIG. 6. *Priory of Saint-Sauveur.*

from 824 until his death in 859.[12] In Arles, in the south of France, as reported by Danièle Foy, a colored glass tile (Th. 1.8 cm) was found in the vicinity of Saint-Cézaire in a fifth-century context.[13] Also in France, Christian Sapin mentioned the tiles from the third church of Cluny Abbey at the beginning of the 12th century, as well as possible parallels discovered in 1840 at the Abbey of Saint Bertin (Saint-Omer) and the Collegiate Church (now Basilica) of Saint-Quentin.[14]

To the north, pieces comparable to the tiles from Saint-Sauveur were found at the Imperial Abbey of Corvey, near Höxter in Germany. The shape of the German tiles is different, however. The most complete examples are octagonal

13. Danièle Foy, "Les Revêtements muraux en verre à la fin de l'Antiquité: Quelques témoignages en Gaule méridionale," *Journal of Glass Studies*, v. 50, 2008, pp. 51–65.

14. Sapin [note 1], p. 225.

pieces made of dark glass. Their dimensions are close to those of the Saint-Sauveur tiles, but their glass has many inclusions that may be related to the melting of slag.[15] According to Francesca Dell'Acqua, this glass was melted on a surface and then shaped with a metal or wooden tool. The surface of the tiles was smoothed, and these pieces have an irregular thickness. The external color is due to alteration. The original pieces contained glass of different colors: black, red, white, and red with traces of green.[16] The imprints that they left in the mortar found on the site demonstrate that they served as wall decorations.[17] Other Carolingian tiles are known from Minden, Münster, and Hildesheim, but they are much more fragmentary.[18]

It is interesting to note that Louis the Pious, who provided for the priory of Saint-Sauveur, also supported the Imperial Abbey of Corvey, founded in 822. About 839, Warin I (about 800–856), abbot of Corvey, wrote to the Alemannic Benedictine monk and theological writer Walafrid Strabo at Reichenau to ask that Matthew be sent to him to make glass for the church and to teach the craft of glassmaking to his community.[19] According to Dell'Acqua, the tiles of Corvey, Hildesheim, Münster, and Minden could be attributed to a single workshop.[20] Perhaps the priory of Saint-Sauveur also benefited from these artisans, or was at least inspired by them.

According to the written sources, the priory of Saint-Sauveur was of early medieval origin and provided for by the Carolingian kings. Comparisons with the sites of Corvey and Sant'Ambrogio also indicate an early medieval date for

15. Francesca Dell'Acqua, "Glasfliesen," in *Die Klosterkirche Corvey: Geschichte und Archäologie*, ed. Sveva Gai, Karl Heinrich Krüger, and Bernd Their, Denkmalpflege und Forschung in Westfalen, v. 43, no. 1.1, Darmstadt: Philipp von Zabern, 2012, p. 416.
16. Lobbedey, Dell'Acqua, and Wedepohl [note 3], pp. 92–94.
17. *Ibid.*, pp. 89–90.
18. *Ibid.*, p. 91.
19. *Ibid.*, p. 97.
20. *Ibid.*

TABLE 1

Compositions (in Wt % of Oxides) of Tiles from Saint-Sauveur

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO
Coll. Bacot 1 blue	2.80	1.04	4.90	63.3	2.17	0.97	0.44	4.75	15.8
Coll. Bacot 1 white	1.58	1.06	3.50	41.2	1.91		0.56	3.36	11.0
Coll. Bacot 1 red	2.48	2.40	4.12	56.4	2.03	0.87	0.46	4.53	20.2
Coll. Bacot 1 blue (break)	2.33	3.16	3.19	60.6	2.09		0.49	4.44	20.1
Dijon 1 blue	2.85	1.75	4.26	61.7	1.67	0.91	0.59	4.53	18.7
Dijon 1 red	2.45	0.94	5.45	64.8	1.48	1.12	0.33	3.97	13.9
Dijon 1 white	1.60	0.85	4.11	44.4	1.16		0.36	3.33	10.2
Dijon 2 blue	2.35	1.04	4.79	65.8	1.48	0.90	0.48	4.26	16.0
Dijon 2 red	2.08	0.96	5.29	62.2	1.71	0.88	0.42	4.23	15.8
Dijon 2 white	1.52	1.29	3.12	40.4	1.58		0.60	3.04	12.1
NIST 620 (average)	14.57	14.76	3.59	1.92	72.22	n.d.	0.23	n.d.	0.36
NIST 620 (std. deviation)	0.08	1.18	0.02	0.04	0.85		0.02		0.02

Analysis obtained by PIXE-PIGE. n.d. = not detected.

the glass tiles. However, the very good state of preservation and the uncertain context of discovery allow us to question this dating. To determine whether the eight Saint-Sauveur tiles belong to the same cluster, as well as to confirm their early medieval date, we decided to study all of them in detail and to analyze the materials of the objects.

Experimental

An initial macroscopic examination was carried out with the naked eye and a binocular lens. This allowed us to observe manufacturing traces, as well as traces left by use and restoration.

Next, François Mathis and Myrtho Bonnin performed analyses in PIXE-PIGE on the cyclotron of the Institut de Physique Nucléaire Atomique et Spectroscopie (IPNAS) at the University of Liège.[21] Three tiles were analyzed: the two from the museum in Dijon and one from the collection of Jacques Bacot. For each of these objects, two to four points were analyzed on each color. On the Bacot tile, a fresh break gave the researchers access to unaltered glass. On the other pieces, even if not visible, weathering might have disturbed the measurement. This process might concern, in particular, alkali (sodium and potassium) and alkaline earths (magnesium and calcium) leached out of the glass. It can also affect silica and alumina (Table 1).[22]

The two tiles from Dijon, the second tile from Mr. Bacot's collection, and the four tiles from Autun were examined by LA-ICP-MS at the Institut de Recherche sur les Archéomatériaux, Centre Ernest-Babelon, at the University of Orléans. The ablation system consists of a Resonetics M50E excimer laser working at 193 nm,

21. For the description of the methods, see Line Van Wersch and others, "Analyses of Early Medieval Stained Window Glass from the Monastery of Baume-les-Messieurs (Jura, France)," *Archaeometry*, v. 58, pt. 6, December 2016, pp. 930–946.

22. Jérôme Sterpenich and Guy Libourel, "Water Diffusion in Silicate Glasses under Natural Weathering Conditions: Evidence from Buried Medieval Stained Glasses," *Journal of Non-Crystalline Solids*, v. 352, nos. 50/51, 2006, pp. 5446–5451.

TiO_2	MnO	Fe_2O_3	CoO	NiO	Cu_2O	ZnO	As_2O_5	Rb_2O	SrO	SnO_2	PbO
0.21	0.66	1.24	0.080	0.019	0.082	0.059	0.23	0.0095	0.081	0.61	1.27
0.15	0.33	0.65	0.055	0.012	0.025	0.034	0.13		0.045	10.7	23.3
0.21	0.80	2.17		0.009	3.03	0.036		0.0072	0.080	0.25	0.50
0.19	0.73	1.02	0.085	0.017	0.082	0.027	0.24	0.0081	0.076	0.41	0.80
0.18	0.60	0.92	0.094	0.022	0.071	0.060	0.29	0.0082	0.074	0.54	0.85
0.20	0.53	1.18	0.054	0.015	2.05	0.12	0.12	0.010	0.075	0.73	0.92
0.15	0.30	0.55			0.016	0.068			0.038	10.8	21.4
0.20	0.64	1.09	0.071	0.017	0.041	0.10	0.23		0.069	0.34	0.45
0.22	0.66	2.29			2.30	0.15			0.079	0.32	0.49
0.15	0.34	0.65		0.015	0.024	0.045			0.048	10.5	24.3
6.71	0.016	n.d.	0.04	n.d.	n.d.	n.d.	n.d.	0.0837	n.d.	0.0344	0.0291
0.08	0.00		0.01					0.0104		0.0053	0.0045

coupled with a Thermo Fisher Scientific ELEMENT XR mass spectrometer. One or two ablation passes were performed for each type of glass, and the average was calculated. National Institute of Standards and Technology (NIST) standard reference materials 610, along with Corning reference glasses B, C, and D and an in-house standard glass, were employed for external standardization.

Concentrations were calculated according to Bernard Gratuze.[23] There was no special preparation for the samples, but because the glass tiles

23. Bernard Gratuze, "Glass Characterization Using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry Methods," in *Recent Advances in Laser Ablation ICP-MS for Archaeology*, ed. Laure Dussubieux, Mark Golitko, and Bernard Gratuze, Natural Science in Archaeology, Heidelberg and Berlin: Springer, [2016], pp. 179–196.

TABLE 2

Major and Minor Oxide Compositions in Tiles from Saint-Sauveur

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	Cl	K_2O
Autun 1 blue	1.98%	2.84%	3.05%	59.8%	3.37%	0.38%	4.13%
Autun 1 red	2.05%	2.76%	3.14%	58.4%	2.74%	0.50%	4.50%
Autun 1 white	1.31%	1.90%	2.40%	48.0%	2.17%	0.47%	3.13%
Autun 2 blue	1.88%	2.88%	3.12%	60.3%	3.04%	0.61%	4.26%
Autun 2 red	1.79%	2.92%	3.45%	57.6%	2.85%	0.50%	4.05%
Autun 2 white	1.36%	1.87%	2.47%	45.5%	1.91%	0.43%	3.17%
Autun 3 blue	2.08%	2.79%	2.96%	60.1%	3.61%	0.97%	3.87%
Autun 3 red	1.83%	2.49%	3.10%	60.3%	3.08%	0.69%	3.76%
Autun 3 white	1.42%	1.70%	2.51%	47.3%	1.98%	0.48%	2.76%
Autun 4 blue	1.77%	2.91%	2.99%	59.6%	3.15%	0.77%	3.96%
Autun 4 red	1.77%	3.13%	3.27%	58.0%	2.90%	0.67%	3.76%
Autun 4 white	1.51%	2.14%	2.58%	51.2%	2.44%	0.79%	3.29%
Coll. Bacot 2 blue	1.72%	2.64%	2.74%	63.1%	3.80%	0.83%	3.71%
Coll. Bacot 2 red	1.54%	2.38%	2.84%	62.8%	3.21%	0.81%	3.46%
Coll. Bacot 2 white	1.08%	1.59%	2.20%	45.3%	2.22%	0.44%	2.92%
Dijon 1 blue	1.92%	2.70%	2.83%	63.0%	3.42%	0.88%	4.38%
Dijon 1 red	1.88%	2.60%	2.92%	61.3%	3.04%	0.64%	4.26%
Dijon 1 white	1.12%	1.63%	2.30%	48.4%	2.21%	0.60%	2.69%
Dijon 2 blue	1.69%	3.06%	3.03%	61.2%	3.16%	0.58%	4.52%
Dijon 2 red	1.64%	3.10%	3.41%	57.8%	2.97%	0.42%	4.40%
Dijon 2 white	1.28%	1.79%	2.38%	42.8%	2.02%	0.28%	3.21%
Corn. A average	13.3%	2.55%	0.91%	67.7%	0.12%	0.11%	2.75%
Corn. A std. deviation	0.4%	0.06%	0.02%	0.7%	0.06%	0.03%	0.13%
NIST 612 average	13.9%	0.011%	2.10%	71.1%			
NIST 612 std. deviation	0.3%	0.002%	0.03%	0.6%			

do not fit in the standard Resonetic S155 analytical cell, they were analyzed in a cell specially designed for the study of large objects (up to 40 x 40 x 13 cm).[24] To ensure the compatibility of the data with other analyses carried out in the standard cell, reference materials Corning A and NIST SRM612 were analyzed with the tiles (Table 2).

24. Nadine Schibille and others, "Comprehensive Chemical Characterisation of Byzantine Glass Weights," *PLoS ONE*, 2106, v. 11, no. 12, December 13, 2016, https://doi.org/10.1371/journal.pone.0168289.

RESULTS

Macroscopic Examination

At first glance, the eight tiles appear to be opaque black. However, the matrix is made of translucent deep blue glass, with inserted trails of opaque red and white glass. While Dell'Acqua

CaO	*TiO_2*	*MnO*	*Fe_2O_3*	*CuO*	*SnO_2*	*PbO*	*Li_2O*	*B_2O_3*
20.8%	0.18%	0.62%	0.80%	0.084%	0.15%	1.21%	60.4	544
20.0%	0.17%	0.60%	1.02%	3.61%	0.012%	0.10%	47.7	608
12.6%	0.13%	0.34%	0.57%	0.027%	5.71%	20.8%	62.1	363
20.6%	0.17%	0.70%	0.98%	0.068%	0.21%	0.51%	73.6	568
20.6%	0.19%	0.72%	2.10%	2.31%	0.13%	0.31%	72.9	563
12.6%	0.12%	0.35%	0.59%	0.026%	5.89%	23.0%	48.1	383
20.5%	0.16%	0.60%	0.72%	0.34%	0.13%	0.32%	72.1	552
19.1%	0.18%	0.57%	1.14%	3.07%	0.0079%	0.05%	52.7	482
12.5%	0.14%	0.35%	0.65%	0.037%	5.48%	20.8%	49.7	347
19.8%	0.17%	0.66%	0.94%	0.052%	0.33%	1.99%	81.8	538
20.1%	0.18%	0.71%	2.11%	2.16%	0.15%	0.34%	85.0	528
13.5%	0.13%	0.39%	0.62%	0.030%	3.12%	17.7%	62.1	381
18.9%	0.17%	0.59%	0.69%	0.025%	0.12%	0.28%	59.0	544
17.5%	0.17%	0.54%	0.99%	2.91%	0.0082%	0.30%	50.7	485
12.6%	0.14%	0.30%	0.50%	0.019%	9.39%	20.9%	39.4	340
18.2%	0.16%	0.58%	0.78%	0.023%	0.12%	0.28%	48.0	576
17.7%	0.16%	0.58%	1.03%	3.32%	0.0055%	0.03%	44.8	576
10.7%	0.12%	0.31%	0.53%	0.021%	8.20%	20.5%	67.3	353
19.5%	0.16%	0.74%	0.89%	0.036%	0.20%	0.61%	66.0	607
20.1%	0.17%	0.75%	2.00%	2.42%	0.12%	0.33%	53.6	598
12.9%	0.13%	0.36%	0.59%	0.028%	7.30%	24.3%	46.9	372
5.47%	0.80%	1.03%	1.13%	1.12%	0.17%	0.060%	97.2	1741
0.17%	0.08%	0.03%	0.04%	0.04%	0.006%	0.004%	6	66.4
12.6%	0.0066%	0.0038%		0.0045%	0.0058%	0.0041%	69.2	325
0.5%	0.0009%	0.0014%		0.0005%	0.0015%	0.0015%	17	166

TABLE 2 (Cont.)

	V_2O_5	Cr_2O_3	CoO	NiO	ZnO	GaO	As_2O_3	Rb_2O	SrO
Autun 1 blue	21.4	27.0	713	166	317	5.69	1167	48.4	578
Autun 1 red	33.5	19.0	408	117	304	5.39	249	54.0	591
Autun 1 white	17.2	24.5	600	129	250	4.94	708	43.4	393
Autun 2 blue	25.2	25.7	824	186	285	6.02	1748	54.7	594
Autun 2 red	66.0	38.4	194	64.3	254	6.46	134	54.2	578
Autun 2 white	16.0	20.5	1328	222	205	4.15	2756	42.3	378
Autun 3 blue	20.9	30.4	559	155	373	6.97	1460	48.5	560
Autun 3 red	33.6	36.5	347	125	580	6.21	290	64.3	548
Autun 3 white	17.8	35.5	4624	805	210	4.90	7678	40.9	360
Autun 4 blue	24.5	48.3	707	183	319	6.01	1854	52.9	596
Autun 4 red	69.2	57.4	189	67.3	253	6.96	151	52.3	607
Autun 4 white	18.6	30.5	128	68.2	241	5.21	232	46.5	419
Coll. Bacot 2 blue	21.9		618	140	376	6.16	1161	39.4	530
Coll. Bacot 2 red	33.9		300	96.7	402	6.10	238	42.0	532
Coll. Bacot 2 white	15.5	39.7	463	94.3	218	4.27	617	35.1	330
Dijon 1 blue	21.7	8.9	791	167	399	6.20	1878	47.2	546
Dijon 1 red	32.6	12.0	317	106	471	6.00	235	48.3	559
Dijon 1 white	16.5		495	104	243	4.94	673	33.2	313
Dijon 2 blue	23.1	17.5	661	159	315	5.61	1579	50.6	626
Dijon 2 red	66.0	22.6	184	55.9	281	6.38	115	49.5	625
Dijon 2 white	15.1		1306	205	200	4.21	2052	38.5	370
Corn. A average	62.4	34.9	1723	229	543	1.27	30.4	87.0	982
Corn. A std. deviation	2.77	12.0	35	17	29	0.38	2.7	7.4	24
NIST 612 average	68.7	14.2	39.9	44.5	51.3	46.3	45.2	34.7	89.9
NIST 612 std. deviation	1.9	19.5	7.0	5.7	0.4	0.7	2.4	0.6	2.2

Y_2O_3	ZrO_2	Nb_2O_3	MoO	Ag	Sb_2O_3	Cs_2O	BaO	La_2O_3	CeO_2
10.9	149	3.63	6.92	7.68	5.69	0.93	1120	18.0	35.4
10.9	139	3.67	2.37	27.8	44.9	1.00	1238	17.5	35.2
7.37	94.9	3.10	3.79	46.9	196	1.27	645	13.1	26.0
10.6	139	3.86	8.17	2.08	7.44	1.26	1380	17.1	33.7
12.5	144	3.83	3.53	12.2	28.4	1.14	1447	17.8	36.0
7.33	99.6	2.51	9.40	55.8	192	0.84	674	12.4	25.1
10.0	142	3.70	6.12	4.16	10.7	0.33	1016	16.6	31.6
10.6	140	3.50	1.91	22.4	47.3	1.33	1168	17.2	34.9
7.44	111	2.66	10.4	42.3	205	0.73	660	12.7	26.6
10.3	136	3.08	8.42	16.6	14.3	1.08	1209	16.0	32.5
12.2	136	3.66	3.21	13.7	26.1	0.65	1264	16.4	33.1
8.39	94.6	3.16	3.74	33.5	128	1.02	704	12.7	25.6
9.41	132	3.57	7.40	1.08	6.07	0.90	892	17.6	32.5
9.44	125	3.64	2.18	31.9	53.0	1.01	914	17.2	31.4
7.00	126	3.12	3.32	34.8	209	0.87	524	11.9	22.8
8.84	120	3.41	8.17	1.63	4.94	1.22	909	16.1	32.4
9.17	120	3.59	2.31	24.2	49.2	1.26	1000	16.5	31.5
7.15	89.7	2.78	3.85	43.9	211	1.01	505	12.6	23.1
9.54	125	3.68	8.02	9.62	6.72	1.08	1320	16.4	31.9
12.0	133	4.10	3.29	15.0	25.6	1.07	1354	17.7	35.2
7.37	110	2.92	8.65	48.4	193	0.94	660	12.3	24.2
	51.6		2.8	15	16575		4477		
	1.6		0.4	0.7	495		164		
47.5	52.3	43.8	41.0	23.0	43.2	43.8	44.8	44.4	47.6
1.5	1.8	1.0	1.1	2.1	6.5	2.2	2.0	1.7	2.0

TABLE 2 (Cont.)

	PrO_2	Nd_2O_3	Sm_2O_3	Eu_2O_3	Gd_2O_3	Tb_2O_3	Dy_2O_3	Ho_2O_3
Autun 1 blue	3.70	13.5	2.35	0.50	1.98	0.06	1.61	0.25
Autun 1 red	3.89	13.7	2.24	0.47	1.93		1.64	0.29
Autun 1 white	3.18	9.55	1.82	0.26	1.57	0.05	1.13	0.21
Autun 2 blue	3.67	12.7	2.17	0.55	2.14	0.19	1.54	0.27
Autun 2 red	3.65	13.9	2.70	0.64	2.24		1.81	0.38
Autun 2 white	2.70	9.56	1.52	0.16	1.25	0.06	1.00	0.083
Autun 3 blue	3.31	11.8	2.64	0.29	2.44		1.01	
Autun 3 red	3.28	12.9	2.17	0.16	1.97	0.12	1.39	0.11
Autun 3 white	2.45	9.08	1.41	0.00	1.17		0.55	
Autun 4 blue	2.73	12.2	2.32		1.72	0.29	1.23	
Autun 4 red	3.50	12.4	2.12	0.11	2.02	0.53	1.64	0.05
Autun 4 white	2.42	9.24	1.66	0.29	1.42	0.14	0.76	
Coll. Bacot 2 blue	3.02	10.6	1.72	0.33	1.01	0.18	1.20	0.18
Coll. Bacot 2 red	2.94	10.2	1.78	0.38	0.96	0.20	1.22	0.22
Coll. Bacot 2 white	2.33	8.82	1.52	0.31	1.25	0.20	1.02	0.18
Dijon 1 blue	3.03	10.8	1.85	0.47	1.37	0.28	1.26	0.27
Dijon 1 red	3.00	11.0	1.93	0.48	1.40	0.29	1.35	0.27
Dijon 1 white	2.23	8.07	1.42	0.36	0.91	0.22	1.08	0.42
Dijon 2 blue	3.30	12.0	2.02	0.49	1.88	0.30	1.42	0.29
Dijon 2 red	3.59	13.5	2.60	0.59	2.22	0.41	1.87	0.36
Dijon 2 white	2.47	9.76	1.69	0.39	1.95	0.26	1.26	0.19
Corn. A average								
Corn. A std. deviation								
NIST 612 average	45.1	43.4	45.9	42.6	43.0	43.3	41.3	43.8
NIST 612 std. deviation	2.7	1.9	3.0	1.2	1.7	3.3	2.2	3.5

Analysis obtained by LA-ICP-MS. Data reported in wt % of oxides for Na_2O–PbO; concentrations for Li_2O–UO_2 reported in ppm of oxides (1 ppm = 0.0001%).

mentions impurities in the glass from Corvey,[25] the glass from Saint-Sauveur appears to be homogeneous, without any visible inclusions. In the deep blue, white, and red glasses, no inclusions can be seen, and the glass seems to have been produced according to a perfectly mastered process that is contrary to what was observed in Corvey.

The glass is shaped in squares measuring 10 centimeters. The measurable pieces are between 1.2 and 1.7 centimeters thick (Fig. 7) and weigh about 475 grams. The sides are very regular, and no particular traces of shaping or tooling could

25. Lobbedey, Dell'Acqua, and Wedepohl [note 3], p. 93.

Er_2O_3	Tm_2O_3	Yb_2O_3	Lu_2O_3	HfO_2	Ta_2O_3	WO	Bi	ThO_2	UO_2
0.82	0.17	0.87		3.08	0.12	0.76	147	3.38	0.80
0.89	0.15	0.94		2.97	0.19	0.83	14.4	3.48	0.86
0.65	0.11	0.75		1.93	0.08	0.76	78.1	2.51	0.49
0.88	0.22	0.87	0.052	2.98	0.29	0.94	139	3.42	0.77
1.14	0.19	0.85		3.06	0.084	0.79	12.7	4.03	1.00
0.45	0.11	0.50		2.20	0.18	0.63	256	2.74	0.37
		0.37		2.10		0.47	101	2.93	
0.48	0.033	0.83		2.69	0.26	0.76	16.3	3.02	0.91
0.12		0.70		2.05	0.037	0.58	421	2.25	0.29
0.36	0.10	0.79	0.072	2.99	0.27	0.74	141	2.66	0.82
1.25	0.22	1.12	0.29	2.94	0.58	1.02	11.2	3.22	0.48
0.41	0.18	0.83	0.21	1.83	0.20	0.93	28.7	2.38	0.41
0.66	0.035	0.66	0.064	2.90	0.21	0.83	123	3.28	0.75
0.71	0.076	0.66	0.078	2.71	0.23	0.88	11.0	3.45	0.82
0.65	0.048	0.54	0.070	2.98	0.27	0.70	66.7	2.44	0.64
0.72	0.10	0.75	0.13	2.71	0.23	0.94	164	3.07	0.92
0.80	0.062	0.86	0.12	2.68	0.25	0.94	12.6	3.36	0.88
0.57	0.071	0.62	0.10	2.03	0.19	0.79	65.0	2.75	0.61
0.90	0.075	0.84	0.10	2.88	0.23	0.93	140	3.34	0.93
1.11	0.068	1.10	0.16	2.86	0.26	0.93	11.6	4.22	0.98
0.68	0.057	0.76	0.11	2.59	0.19	0.63	197	2.64	0.76
							7.3		
							0.6		
41.7	40.8	46.8	41.6	43.8	36.3	30.4	32.4	43.0	41.1
1.6	3.2	2.5	2.5	1.3	1.4	1.1	1.2	3.0	1.5

be observed. The angles are rounded (Fig. 8). The tiles were shaped by pouring the glass into a mold. Judging by the consistent dimensions, the eight pieces may have come from the same or very similar molds. On the upper face, traces of mixing are visible (Fig. 9). The deep blue glass was first cast in a mold. The opaque red and white glasses were then poured into the deep blue matrix, which was mixed to provide a marbled effect. Pieces of white and red glass could also have been added in the softened matrix. They would then have been fused and mixed. The surface appears to be irregular and was thus probably not flattened.

The four tiles from Autun are inserted in mortar and presented in a very heavy metal frame

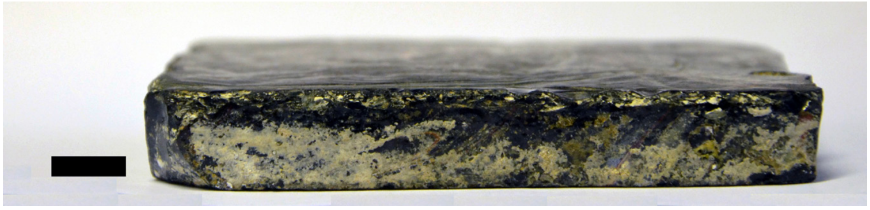

FIG. 7. *Side of Dijon 1, showing traces of mortar.*

FIG. 8. *Rounded corner of Bacot 1.*

(see Figure 3). Their bottom can no longer be observed. The tiles in Dijon are covered with glue and white mortar, both of which are surely due to restoration at the beginning of the 20th century. The pieces from Mr. Bacot's collection are the best-preserved. The bottom of each of those tiles is more irregular and rippled than the upper side. Traces of mixing are clearly visible, but between these lines, the surface of the glass is quite regular and not rough, as is observed on some tesserae poured on sand (Fig. 10). The backs of these tiles are also covered with one thin layer of yellowish gray mortar. This material extended to the sides (see Figure 7). The tiles, imitating marble, were meant to decorate

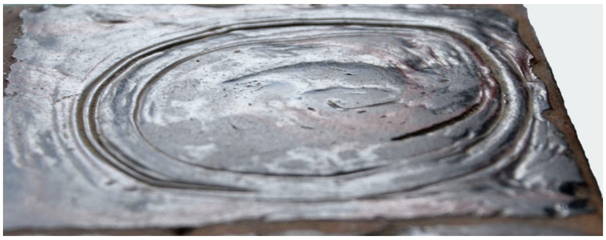

FIG. 9. *Traces of mixing visible on surface of one tile in Autun.*

the floor, in a manner similar to the pavement that can still be seen at the Abbey of Fleury (Saint-Benoît-sur-Loire, Loiret, France).

Some pieces are chamfered on the upper side (Fig. 11). Percussion impacts can be seen, but not on the most recently discovered examples (see Figures 4 and 8). These traces could be due to extraction of the initial support and/or reworking and replacing the tiles.

Chemical Analyses

ICP-MS and PIXE analyses have already been associated with glass studies, such as research on the provenance of obsidian.[26] In the present case, the differences observed between the two sets of measurements are due to weathering on the glass surface that cannot be avoided in PIXE measurements. This phenomenon is known and

26. Ludovic Bellot-Gurlet and others, "Obsidian Provenance Studies in Archaeology: A Comparison between PIXE, ICP-AES and ICP-MS," *Nuclear Instruments & Methods in Physics Research, Section B, Beam Interactions with Materials and Atoms*, v. 240, no. 1, 2005, pp. 583–588.

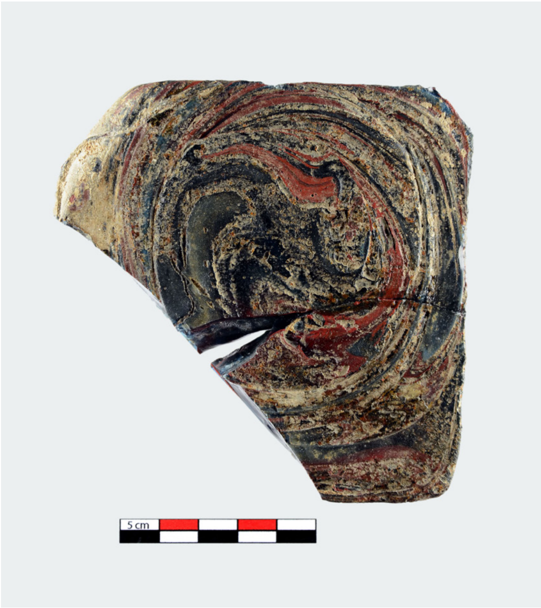

FIG. 10. *Back of Bacot 1.*

FIG. 11. *Traces of percussion on Dijon 2.*

documented in various papers on this method.[27] Here, the values provided by PIXE analyses reflect another state of the glass on another part of the objects than the values obtained by LA-ICP-MS. Despite analytical problems, the weathered glass composition is similar on the three objects analyzed by PIXE, suggesting that they belong to the same group. Nevertheless, our interpretation regarding glass composition will be based on analyses of pristine glass obtained by LA-IPC-MS. PIXE analyses will be used to resolve some issues that can be raised by this method.

The Glass Composition

It appears that the glass is of a wood-ash composition (see Tables 1 and 2). Next to the silica, it has a large amount of calcium (up to 20%). The alkalis are low: potassium varies from 2.69% to 4.7%, and sodium from 1.08% to 2.85%. These elements probably came from plant ash, and possibly from the addition of sodium chloride. According to Caroline Jackson and co-authors, the ash compositions vary for many reasons relating to the tree, to the season in which it was cut down, to the soil, and to the climate.[28] It is impossible to characterize the plant that was involved in producing the glass. The artisans probably employed the plant species that were in use at that time. Still, the type of glass employed is the same for the eight tiles.

This composition is peculiar for the early Middle Ages. Indeed, at that time, most glass continued to be made with natron and sand, according to the Roman tradition, which rested partly on recycling and had a composition with

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27. Ž[iga] Šmit, "Ion-Beam Analysis Methods," in *Modern Methods for Analysing Archaeological and Historical Glass*, v. 1, ed. Koen Janssens, Chichester, West Sussex, U.K.: John Wiley & Sons Inc., 2013, pp. 155–184; T[homas] Calligaro, "PIXE in the Study of Archaeological and Historical Glass," *X-Ray Spectrometry*, v. 37, no. 2, March/April 2008, pp. 169–177; G[eorges] Weber and others, "What Can Bring the PIXE-PIGE Method to the Study of Stained Glass Window?," in *COST Action G8: Non-Destructive Testing and Analysis of Museum Objects*, ed. Andrea Denker and others, Stuttgart: Fraunhofer IRB, 2006, pp. 152–160, esp. p. 152.

28. C. M. Jackson, C. A. Booth, and J. W. Smedley, "Glass by Design? Raw Materials, Recipes and Compositional Data," *Archaeometry*, v. 47, pt. 4, November 2005, pp. 781–795, esp. p. 791.

high sodium, low potassium, and low magnesium[29] that does not match the composition of the tiles. On the other hand, soda-ash glass was available in the eastern Mediterranean at that time,[30] but its composition, too, was very different from that of the tiles.

Around the beginning of the ninth century, a third option appeared: glass made of wood ash and sand. This recipe seems to accord with the tiles. However, according to Karl Hans Wedepohl and his analyses of German glass, each medieval period has a characteristic wood-ash glass composition. During the early Middle Ages, from 780 to 1000, glass had quite a low level of potassium (~9.3%). The lack of alkali was corrected by the addition of sodium in the form of salt (NaCl ~2.5%, Ca:K ratio ~1.9).[31] In the tiles from Saint-Sauveur, the Ca:K ratio is close to 5 (mean of 4.63), and the potassium is lower (~3.7%).

The results presented in this article are close to those published by Wedepohl.[32] In his study, one unidentified piece from Saint-Sauveur was analyzed, in addition to pieces from Corvey. According to Wedepohl, the composition of the Saint-Sauveur piece could match that of early medieval glass. It is very close to the composition of a vessel found in Rouen but quite different from that of the tiles from Corvey that Wedepohl dated to the Romanesque period, contrary to archaeologists who placed these objects in the Carolingian period.[33]

Among the more recent data, the best match for the composition of the Saint-Sauveur tiles can be High Lime Low Alkali (HLLA) glass. The latest findings have about 20 percent calcium and seven percent alkali (Na+K). This type of glass has been identified in various countries after the 15th century. In England, following the mid-16th century, potash glass was replaced by mixed-alkali (MA) and HLLA glasses.[34] In the Low Countries, HLLA glass reached its highest level of dissemination in the late 16th century.[35] In Germany, HLLA glass is dated from 1400 to 1800.[36] This glass may have been produced using wood ashes with a higher content of calcium or with the addition of lime.[37] Still, the analyses show that sodium chloride was deliberately added to the batch.[38] So, should the tiles be dated to the 15th century and not to the Carolingian period? The answer might be found in the coloring elements.

Coloring Elements

White. The white glass is present in the smallest quantity. It can be differentiated from the other colors by its high levels of tin (3.12%–9.39%) and lead (9.85%–24.3%), which are responsible for its coloration and opacification.

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29. See, for example, Ian C. Freestone, Michael J. Hughes, and Colleen P. Stapleton, "The Composition and Production of Anglo-Saxon Glass," in *Catalogue of Anglo-Saxon Glass in the British Museum*, ed. Sonja Marzinzik, British Museum Research Publication, no. 167, London: the museum, and Oakville, Connecticut: David Brown Book Co., 2008, pp. 29–46.

30. Julian Henderson, *Ancient Glass: An Interdisciplinary Exploration*, Cambridge, U.K.: Cambridge University Press, 2013, pp. 97–102.

31. Karl Hans Wedepohl, Klaus Simon, and Andreas Kronz, "Data on 61 Chemical Elements for the Characterization of Three Major Glass Compositions in Late Antiquity and the Middle Ages," *Archaeometry*, v. 53, pt. 1, February 2011, pp. 81–102, esp. p. 95.

32. Lobbedey, Dell'Acqua, and Wedepohl [note 3], p. 104.

33. *Ibid*., pp. 104–105.

34. Andrew Meek, Julian Henderson, and Jane Evans, "Isotope Analysis of English Forest Glass from the Weald and Staffordshire," *Journal of Analytical Atomic Spectrometry*, v. 27, no. 5, 2012, pp. 786–795.

35. Joost Caen, Olivier Schalm, and Koen Janssens, "15th Century Stained Glass Windows in the Former County of Flanders: A Historical and Chemical Study Related to Recent Conservation Campaigns," *Annales de l'Association Internationale pour l'Histoire du Verre*, v. 17, Antwerp, 2006 (2009), pp. 459–466.

36. Olivier Schalm, Hilde Wouters, and Koen Janssens, "Composition of Thirteenth to Seventeenth-Century Glass from Non-Figurative Windows in Secular Buildings Excavated in Belgium," *Annales de l'Association Internationale pour l'Histoire du Verre*, v. 16, London, 2003 (Nottingham, U.K., 2005), pp. 352–355.

37. Jerzy J. Kunicki-Goldfinger and others, "The Composition of Window Glass from the Cesspits in the Old Town in Elbląg, Poland," *Annales*, v. 18 [note 10], pp. 395–400.

38. *Ibid*.

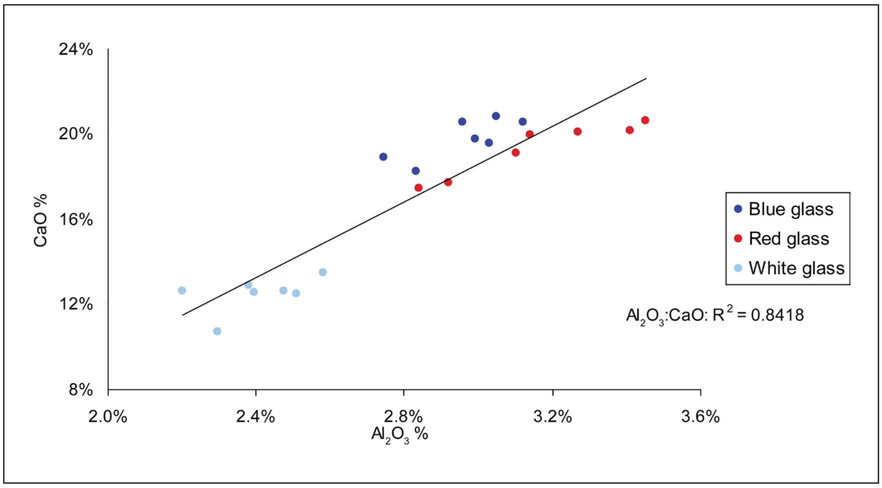

FIG. 12. *Scatter plot showing calcium vs. aluminum (in wt % of oxides) measured by LA-ICP-MS in various colors of tiles from Saint-Sauveur.*

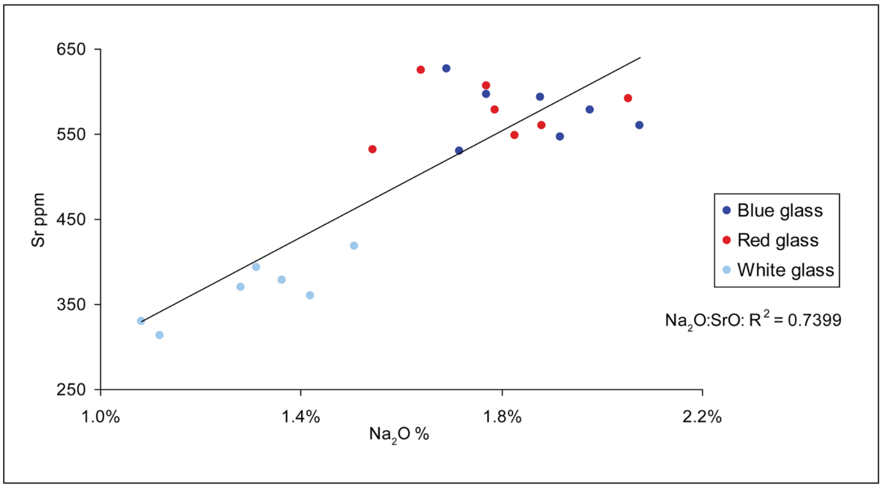

FIG. 13. *Scatter plot showing strontium vs. sodium (in wt % of oxides) measured by LA-ICP-MS in various colors of tiles from Saint-Sauveur.*

Consequently, the ratio of "raw glass components"—silicon and alkali—is reduced. The mixture of lead and tin is about one-third of the composition. The ratio of lead to tin is about 3.5.

A correlation between calcium and aluminum can be observed (Fig. 12). Part of the alumina can probably be attributed to the sand, and part of it to the ashes. Sodium is correlated with potassium, strontium, and manganese. The correlation between sodium and strontium may be due to the fact that lead-tin calx was added in large quantities and diluted the base glass (Fig. 13); this correlation is usually absent in plant-ash glass. The presence of lead-tin calx also explains the higher concentration of antimony and silver (Fig. 14) because these two elements are common impurities in the lead compounds used to produce lead-tin calx.

In some of the white samples (Autun 2 and 3, as well as Dijon 2), LA-ICP-MS analyses showed quite a high concentration of cobalt

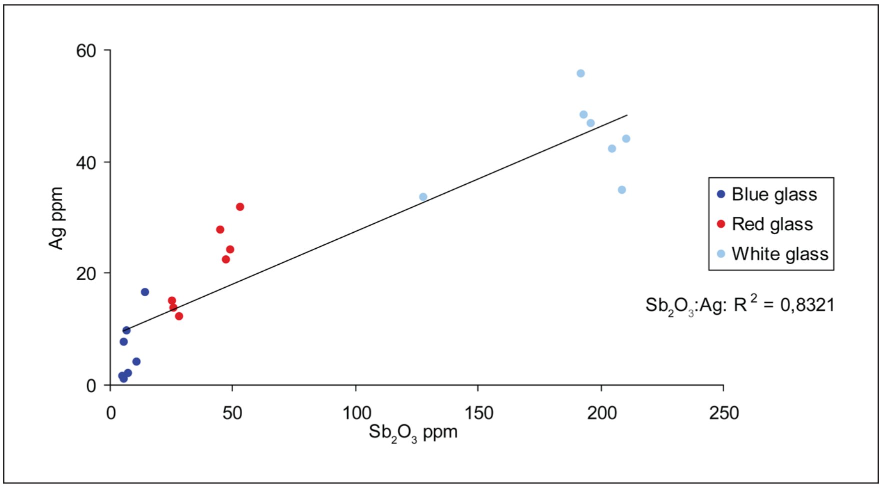

FIG. 14. *Scatter plot showing silver vs. antimony (in wt % of oxides) measured by LA-ICP-MS in various colors of tiles from Saint-Sauveur.*

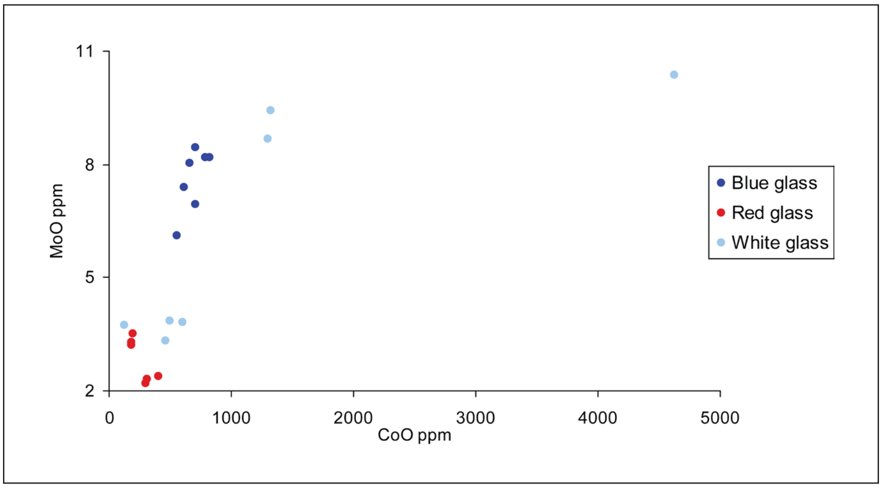

FIG. 15. *Scatter plot showing molybdenum vs. cobalt (in wt % of oxides) measured by LA-ICP-MS in various colors of tiles from Saint-Sauveur.*

and associated elements (see below) (Fig. 15). However, these values are probably due to the laser sampling method (spot instead of line) and the very thin layer of white glass on the blue glass beneath it. Indeed, the surface analyses by PIXE-PIGE on Dijon 2 show a lower content of cobalt.

As a comparison, in San Vincenzo at the beginning of the ninth century, opaque white glass was produced by a completely different process. It was made of Roman white tesserae colored and opacified by calcium antimonate.[39] During the early Middle Ages, coloration and opacification with a mixture of tin and lead is known to have occurred because it has been recorded several times, principally for Merovingian

39. Nadine Schibille and Ian C. Freestone, "Composition, Production and Procurement of Glass at San Vincenzo al Volturno: An Early Medieval Monastic Complex in Southern Italy," *PLoS ONE*, v. 8, no. 10, October 16, 2013, https://doi.org/10.1371/journal.pone.0076479, p. 2.

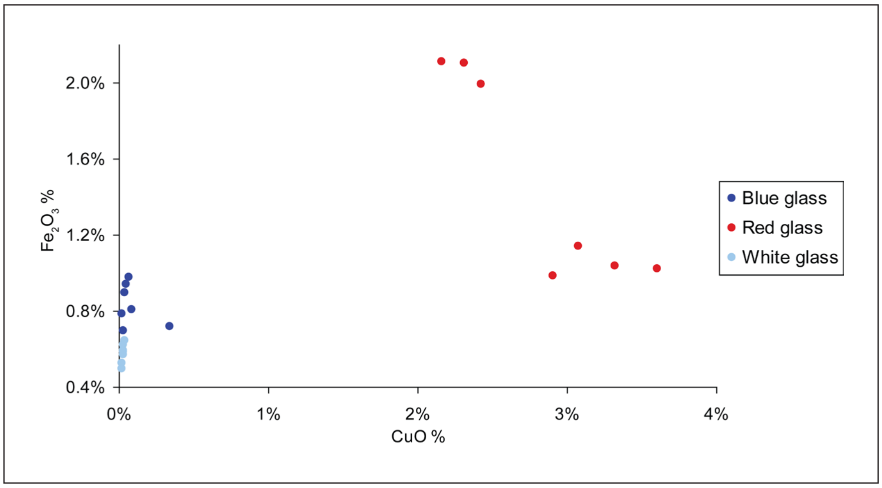

FIG. 16. *Scatter plot showing iron vs. copper (in wt % of oxides) measured by LA-ICP-MS in various colors of tiles from Saint-Sauveur.*

beads.[40] From the fourth century, tin was employed to replace antimony.[41] Recipe books mention lead-tin calx as early as the 14th century, and it continued to be used until the 20th century.[42] Therefore, the process by which the white color was obtained is not helpful for the dating of the tiles.

Red. The red glass is present on the dark glass layer in larger amounts than the white glass. Scholars believe that red glass was produced in a limited number of places within a given region.[43] During the early Middle Ages, despite its abundance in other types of crafts such as enamel and bead production,[44] the presence of red glass in monumental building seems to be restricted, in relation to other colors, and this is also true of the blue glass.[45]

Copper is responsible for the production of the red color (Fig. 16), and glass containing copper had to be maintained under a reducing condition to ensure a successful outcome.[46] In the Saint-Sauveur tiles, copper is present at about two to three percent, and it is correlated with iron and titanium. Iron certainly acted as a reducing agent.[47] In some red glasses, lead can be present in very high quantities,[48] but here it remains low and was not intentionally added to the batch.

40. M. Heck and P. Hoffmann, "Coloured Opaque Glass Beads of the Merovingians," *Archaeometry*, v. 42, pt. 2, August 2000, pp. 341–357.

41. M. Tite, T. Pradell, and A. Shortland, "Discovery, Production and Use of Tin-Based Opacifiers in Glasses, Enamels and Glazes from the Late Iron Age Onwards: A Reassessment," *Archaeometry*, v. 50, pt. 1, February 2008, pp. 67–84, esp. p. 80.

42. Cesare Moretti and Sandro Hreglich, "Raw Materials, Recipes and Procedures Used for Glass Making," in *Modern Methods* [note 27], pp. 23–47, esp. p. 31.

43. A. N. Shugar, "Byzantine Opaque Red Glass Tesserae from Beit Shean, Israel," *Archaeometry*, v. 42, pt. 2, August 2000, pp. 375–384, esp. p. 375.

44. Ian C. Freeestone, Colleen P. Stapleton, and Valery Rigby, "The Production of Red Glass and Enamel in the Late Iron Age, Roman and Byzantine Periods," in *Through a Glass Brightly: Studies in Byzantine and Medieval Art and Archaeology Presented to David Buckton*, ed. Chris Entwistle, Oxford, U.K.: Oxbow Books, and Oakville, Connecticut: David Brown Book Co., 2003, pp. 142–154.

45. L. Van Wersch and others, "Les Vitraux alto-médiévaux de Stavelot (Belgique)," *ArcheoSciences*, v. 38, no. 1, 2014, pp. 219–234.

46. Alberta Silvestri and others, "The Palaeo-Christian Glass Mosaic of St. Prosdocimus (Padova, Italy): Archaeometric Characterisation of Tesserae with Copper- or Tin-Based Opacifiers," *Journal of Archaeological Science*, v. 42, February 2014, pp. 51–67, esp. p. 52.

47. Nadine Schibille and others, "Chemical Characterisation of Glass Mosaic Tesserae from Sixth-Century Sagalassos (Southwest Turkey): Chronology and Production Techniques," *Journal of Archaeological Science*, v. 39, no. 5, May 2012, pp. 1480–1492.

48. Silvestri and others [note 46].

Groups can be distinguished among the tiles (see Figure 16). The first group, consisting of three samples, has iron values around two percent, manganese at about 0.7 percent, and copper between 2.16 and 2.42 percent, while the other samples have lower iron and manganese contents (~1% and 0.6% respectively) and higher copper (~3%). The small differences in manganese are probably attributable to the main glass used to make the red glass. Another difference between the two groups concerns tin, lead, antimony, arsenic, and silver contents, which could have come from the copper. The first group consists of two tiles from Autun, one tile from Dijon, and one of the two tiles owned by Mr. Bacot. The second group is made up of the other two tiles from Autun and one tile from Dijon.

As is demonstrated by recent studies of Venetian red glasses, various recipes were employed to produce red glass. Copper and iron could have come from the use of metal by-products.[49] Texts mention copper and steel scales or filings, iron oxide, or falls from an anvil.[50] This process is attested from antiquity to the modern period, and it has no real chronological value.

To explain the differences in manganese, we must also consider possible contamination of the blue glass in the red material. The high lead values in the red glass of Bacot 2 may be explained by contamination of the glass sampled by the laser with the surrounding glass (either white or blue).

Dark blue. Dark glass, which constitutes the principal material of the tiles, is deep blue in color. Cobalt, in amounts ranging from 0.07 to 0.09 percent, is responsible for this color.

During the Carolingian period, cobalt-blue glass is found infrequently. For the production of blue windows, as mentioned by Theophilus,[51] the glass seems to have come from the recycling of Roman glass tesserae.[52] The number of tesserae needed to make a single glass tile, such as one from Saint-Sauveur, should be close to 240. Roman tesserae are made of natron glass, in which cobalt is associated with iron, nickel, and copper.[53] Because the composition of the tiles is completely different, the recycling of Roman material can be rejected in considering the manufacture of the Saint-Sauveur tiles.

In our tiles, cobalt is correlated with arsenic, nickel, molybdenum, and bismuth (see Figure 15). Thanks to research conducted on European medieval and modern cobalt ores,[54] successive sources of cobalt employed between the late 12th and 18th centuries are well characterized.[55] According to these contributions, the chemical association between cobalt, arsenic, bismuth, nickel, and molybdenum observed in the tiles of Saint-Sauveur is unknown in European objects before the first quarter of the 16th century. It is characteristic of the cobalt ore that originated in the Ore Mountains (Erzgebirge) region of Germany. These results are in good agreement with those drawn from the base-glass composition classified as HLLA glasses, and they show that these tiles should be dated after the end of the 15th century and not from the Carolingian period.

CONCLUSIONS

Analyses of the tiles confirm that all of these objects were made with the same type of glass. The chemical compositions of the various colors

49. Ian C. Freestone, "Primary Glass Sources in the Mid First Millennium AD," in *Annales de l'Association Internationale pour l'Histoire du Verre*, v. 15, New York and Corning, 2001 (Nottingham, U.K., 2003), pp. 111–115.

50. Moretti and Hreglich [note 27], p. 32, where the authors describe the last of these as "a dross obtained when forging or beating steel for knife production."

51. Theophilus, *Diversarum artium schedula, liber secundus*, Paris: Libraire du Dictionnaire des Arts et Manufactures, 1876, chap. 15.

52. Schibille and Freestone [note 39].

53. Bernard Gratuze, "Provenance Analysis of Glass Artefacts," in *Modern Methods* [note 42], pp. 311–343.

54. B. Gratuze and others, "De l'origine du cobalt: Du verre à la céramique," *Revue d'Archéométrie*, v. 20, 1996, pp. 77–94; A. Zucchiatti and others, "The 'Della Robbia Blue': A Case Study for the Use of Cobalt Pigments in Ceramics during the Italian Renaissance," *Archaeometry*, v. 48, pt. 1, February 2006, pp. 131–152.

55. Gratuze [note 53], p. 323.

are nearly identical. The tiles were produced in the same sizes and with the same shaping technique. This leads to the supposition of a common origin and dating.

Comparison with Carolingian objects, as well as the presence of an abbey around the ninth century, caused the tiles to be initially regarded as of early medieval date. Although this period constituted an experimental phase in glass production, with several coexisting types of glass and the appearance of wood-ash glass that resulted in various compositions,[56] the high level of calcium and the low level of alkali recorded in the tiles of Saint-Sauveur indicate a later dating. This is confirmed by the date of the base glass used to obtain the blue glass that is attested in Europe only from the first quarter of the 16th century.

The tiles of Saint-Sauveur definitely appear to be unusual pieces. Although they were initially believed to have been made in the early Middle Ages, their chemical composition demonstrates that they are of much later date—about the beginning of the 16th century, according to their cobalt ore. It is possible that the tiles in our possession are copies of more ancient pieces. According to written testimonies, our tiles or older ones were present in the church at Saint-Sauveur in the 17th century. Excavation at the site could be the only means of definitively dating these pieces and confirming the Carolingian origin of the building. If these excavations lead to the discovery of new glass tiles, they could be analyzed either by PIXE-PIGE or by LA-ICP-MS to compare them to the tiles presented in this article.

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56. Van Wersch and others [note 45].