

# Stained Glass from Saint-Jean-des-Vignes (Soissons) and Comparisons with Glass from Other Medieval Sites

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THE ABBEY of Saint-Jean-des-Vignes has dominated the urban landscape of the northern French city of Soissons since the 11th century.<sup>1</sup> Formally established in 1076, the abbey was built, rebuilt, sacked, and restored from its founding to the present day. In its Gothic phase, the church measured more than 86 meters in length, and its west facade stood 80 meters at its tallest point. The monastic complex, built to accommodate 90 resident canons, effectively communicated the status of the community within the region.<sup>2</sup> From their hilltop in Soissons, the canons administered their holdings, consisting of more than 40 parishes and nearly 20 farms and mills.<sup>3</sup> Today, remnants of the abbey's Gothic splendor may be

glimpsed in the west facade, refectory, and cloister, all of which still stand on the site.

Although it has long been known as an important Gothic monument, the abbey was not systematically studied until excavations began in 1982 under the auspices of MonArch, the Wesleyan-Brown Monastic Archaeology Project. Excavation and research have focused on the Romanesque and Gothic churches, claustral ranges, latrine building, and the abbey's complex water management system.

Surviving sculptural and painted decoration, as well as excavated sculpture, plaster, wall-painting fragments, and tiled floors, attests to the nature of the decoration at the abbey during each of its major phases.<sup>4</sup> The recovery of

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*Acknowledgments.* Like all collaborative efforts, this project is the work of many people and several institutions. We are especially grateful to Profs. Sheila Bonde of Brown University and Clark Maines of Wesleyan University, directors of the research project at Saint-Jean-des-Vignes. We extend our thanks to Jean-Olivier Guilhot, former conservateur régional of the Service Régional de l'Archéologie de Picardie, and Dominique Roussel, conservateur of the Musée Municipal de Soissons, who made the samples available for examination and analysis. We also thank the numerous donors of the glass fragments from the other sites included in the statistical calculations. Those donors are named in the original publication of our data (see note 14). The fieldwork of Patricia Pongracz on the abbey's stained glass was supported by the Wesleyan-Brown Monastic Archaeology Project at the Augustinian abbey of Saint-Jean-des-Vignes (MonArch) and by a Rakow Grant for Glass Research, which was awarded to her by The Corning Museum of Glass in 1999. Stephen Koob helped with the sample preparations, and Shana Wilson assisted in handling the data and creating the graphs. Both are with The Corning Museum of Glass.

1. On Saint-Jean, see, most recently, *Saint-Jean-des-Vignes in Soissons: Approaches to Its Architecture, Archaeology and*

*History*, ed. Sheila Bonde and Clark Maines, v. 15 of *Bibliotheca Victorina*, Turnhout: Brepols, 2003. Field reports for all excavation seasons from 1994 are available online at the MonArch Web site, [www.wesleyan.edu/monarch](http://www.wesleyan.edu/monarch).

2. For the number of canons living there, see Sheila Bonde, Edward Boyden, and Clark Maines, "Centrality and Community: Liturgy and Gothic Chapter Room Design at the Augustinian Abbey of Saint-Jean-des-Vignes, Soissons," *Gesta*, v. 29, no. 2, 1990, pp. 210–211. Bonde and Maines have aptly characterized the architecture at Saint-Jean-des-Vignes, stating that the west facade in particular "gave material form to the spiritual and political ambitions of its community," in *Saint-Jean-des-Vignes* [note 1], p. 189.

3. For the abbey's holdings, see Edward Boyden and Clark Maines, "Monastic Settlement and the Abbey's Domain," in *Saint-Jean-des-Vignes* [note 1], pp. 84–116.

4. For the tile floors in the chapter room, see Sheila Bonde, V. Durey-Blary, and Clark Maines, "Soissons, un pavement gothique à Saint-Jean-des-Vignes," *Archeologia*, no. 308, 1995, pp. 40–48. For the character of the Romanesque and Gothic decorative programs, see *Saint-Jean-des-Vignes* [note 1], pp. 170, 171, and 236.

numerous stained glass fragments at Saint-Jean confirms that glazing programs formed part of the abbey's overall decorative schema.

To appreciate the study of the glass found on the site, a brief overview of the abbey's use and changes to its structure over time will be helpful. Shortly after its foundation in 1076, a Romanesque abbey was built. This was followed, in the 13th century, by an ambitious Gothic building campaign that lasted well into the 15th century. Glazing programs surely would have been incorporated into such a church, and they may have been included in the refectory, chapter room, cloister, and abbot's room.<sup>5</sup>

In 1567, Huguenots sacked the abbey, presumably knocking out much of the stained glass.<sup>6</sup> From 1796 through 1976, the French army used Saint-Jean as a military base, altering the site to accommodate its needs.<sup>7</sup> The church itself, with the exception of the west facade, was sold by the bishop of Soissons for quarry stone early in the 19th century.<sup>8</sup> During the war of 1870 and World War I, the abbey, like much of Soissons in general, suffered severe damage.<sup>9</sup> The result of all these changes is that none of the glass is left *in situ*.

During the 1998 study season at Saint-Jean, a large group of fragments labeled "1951/1952"

was examined, along with fragments revealed by the MonArch project excavations conducted between 1982 and 1996. The "1951/1952" fragments, measuring 7,707 cm<sup>2</sup>, became the standard against which glasses recovered by MonArch were compared. The glass recovered between 1982 and 1996 was measured in two ways. The main sample numbered 2,278 fragments, and another group of fragments had a surface area of about 8,000 cm<sup>2</sup>. All of the glasses were examined by one of the authors (P.P.). This article presents the results of a chemical study of some of these fragments.<sup>10</sup>

On the basis of visual analysis in the field laboratory during the 1998 season, all of the glasses were separated into two categories: grisaille and stained glass. The fragments in each category were classified according to the following criteria: color, presence or absence of decoration, style of decoration where present, nature of grozing, thickness, and weathering.<sup>11</sup> Examples of all types were measured and drawn.<sup>12</sup>

Three types of grisaille glass were excavated at the abbey. There are also stained glasses of four different colors, silver-stained glasses, and two pieces of glass that bear fragmentary figural and foliate motifs. In addition, one intact panel was found. On the basis of style and con-

5. For the phased site plan, see *Saint-Jean-des-Vignes* [note 1], fig. 38.

6. Archeological evidence suggests substantive damage to the site. See *ibid.*, p. 33, and p. 34, n. 19.

7. *Ibid.*, p. 18, and p. 43, n. 30.

8. Bonde, Boyden, and Maines [note 2], p. 190; Sheila Bonde and Clark Maines, "Saint-Jean-des-Vignes: An Augustinian Abbey in Soissons, France," *Archeology*, v. 40, no. 5, September–October 1987, p. 46.

9. For a description of damage sustained by the glazing program of Soissons Cathedral as a result of wars and the city's military occupation, see Madeline Caviness and Elizabeth Pastan, "The Gothic Window from Soissons: A Reconsideration," *Fenway Court, Isabella Stewart Gardner Museum*, 1983, Boston: the museum, 1984, pp. 7 and 9; and Jane Hayward and Walter Cahn, *Radiance and Reflection: Medieval Art from the Raymond Pitcairn Collection*, New York: The Metropolitan Museum of Art, 1982, pp. 138–139. Bonde and Maines note damage sustained by the abbey during these times, in *Saint-Jean-des-Vignes* [note 1], p. 39.

10. Preliminary results of this research were presented in a poster session, "The Excavated Stained Glass of Saint-Jean-

des-Vignes," at the International Conference of the Corpus Vitrearum Medii Aevi, Bristol, England, in 2000, and as the papers "Scientific Investigations of Glass Excavated at the Abbey of Saint-Jean-des-Vignes: Toward a Chronology of the Glazing Programs," XIX International Congress on Glass, Edinburgh, Scotland, 2001, and "Scientific Investigations of Glass Excavated at the Abbey of Saint-Jean-des-Vignes," The Robert Branner Forum for Medieval Art, Columbia University, New York, 2002.

11. Results of the field study were summarized by P. Pongracz in "Vitrail," part of "Saint-Jean-des-Vignes à Soissons: Fouilles programmées de l'ancienne abbaye, Soissons (Aisne). Deuxième rapport provisoire du mobilier des fouilles 1982–1996," ed. S. Bonde and C. Maines, unpublished report of the 1998 study season, pp. 20–25.

12. Analytic drawings were rendered by Nathaniel Stein and Sheila Bonde. In addition to counting the fragments, the surface area of each one was measured, a method employed by Rosemary Cramp ("Window Glass from the Monastic Site of Jarrow: Problems of Interpretation," *Journal of Glass Studies*, v. 17, 1975, pp. 90–92).

text, that panel has been securely dated to the middle of the 13th century.<sup>13</sup>

The glass fragments can be categorized as follows:

#### *Grisaille A*

Fragments of this type typically have an aqua tint, a slightly uneven and pitted surface, and small bubbles within the glass. The edges of these fragments are grozed, except where recent breaks occur. The fragments included both decorated and undecorated glass. The former have brownish red curvilinear and foliate designs on a crosshatched ground. The latter were the same in all physical respects except for their lack of decoration. Ten examples of *Grisaille A* glasses, including both decorated and undecorated fragments, were analyzed chemically.

#### *Grisaille B*

These fragments are undecorated and more nearly colorless than the *Grisaille A* glasses. Fragments of *Grisaille B* glass are smooth, relatively thin (about 2 mm), and free of bubbles. The geometric regularity of these fragments suggests that they were probably set in squares or lozenges (or both). Nine examples were analyzed.

#### *Grisaille C*

A third group of *grisaille* fragments consisted of darker, bluish aqua glass bearing brownish red designs. Glasses of this type have very smooth, even surfaces, and they range in thickness from one to 2.5 millimeters. The glass is relatively free of imperfections, suggesting a refined production process. Original edges, where present, are grozed much more finely than those of the *grisaille* parts of the intact panel or those of the *Grisaille A* glasses.

The decoration on these fragments consists of brownish red curvilinear and crosshatched designs similar to the decoration on the *Grisaille A* fragments. Three examples of *Grisaille C*

glasses, including both decorated and undecorated pieces, were analyzed.

#### *Stained Glass (Colored Glass)*

Most of the stained glass fragments were excavated during the 1951–1952 season. They were found in the interior of the church, in the area of the choir and south transept. The surface area of these fragments totals about 2,600 cm<sup>2</sup>, which is less than the estimated 3,843 cm<sup>2</sup> of the *grisaille* fragments recovered at that time. (However, the latter fragments are generally somewhat larger and better preserved.) The stained glass fragments are two to five millimeters thick, and all of them display weathering in the form of pitting on the exterior surfaces. Where original edges survive, they show evidence of grozing. Both the amber and purple fragments were less well preserved than the other colored glasses.

The stained glass fragments were divided into groups according to color, and then subdivided on the basis of the presence or absence of painted decoration. Some of each color were decorated with motifs applied in brownish red, while others were undecorated. The decoration consisted of curvilinear motifs on a crosshatched ground, in a style entirely compatible with the decorated fragments of *Grisaille A* and the *grisaille* glasses of the intact panel. Only the amber fragments were too weathered and opaque to permit identification of the forms of decoration.

One small fragment (Corning no. 8155) is perhaps unique among the glasses examined. Under some lighting conditions, it appears flesh-colored or a pinkish amber. It is heavily weathered, and it bears no decoration.

The 1951–1952 stained glass fragments that were examined can be grouped according to color, as illustrated in Table 1. This gives some idea of the relative distribution of colors. Forty-seven fragments of the colored glasses were analyzed.

13. See *Saint-Jean-des-Vignes* [note 1], p. 232 and fig. 43.

TABLE 1  
Stained Glass Fragments

<i>Color</i>	<i>Amount Excavated</i>
Amber	69 cm <sup>2</sup>
Blue	832 cm <sup>2</sup>
Purple	98 cm <sup>2</sup>
Ruby flashed/striated	939 cm <sup>2</sup>
Amber, decorated	196 cm <sup>2</sup>
Blue, decorated	312 cm <sup>2</sup>
Purple, decorated	62 cm <sup>2</sup>
Red flashed/striated, decorated	90 cm <sup>2</sup>

### *Historiated Glass*

Two historiated fragments were excavated and analyzed. The first (Corning no. 8169) depicts parts of a male figure. His bearded face and his hand, which holds a staff, are clearly visible. The stickwork on this piece is extremely fine; both the figure's beard and the fingers clutching the staff are delicately rendered. The glass is similar in appearance to Grisaille C. The second fragment, equally finely painted, depicts a leaf in pictorial space, and it is comparable in appearance to Grisaille B. The difference in scale of the painting on the fragments suggests that they are from two distinct roundels, both of which would have been placed at eye level. Placed any higher or farther away, the narratives would have been difficult to read.

### *Silver-Stained Glass*

Three fragments of silver-stained glass were recovered at Saint-Jean. One of them (Corning no. 8170) was selected for analysis.

## CHEMICAL ANALYSES

Seventy-six of the stained glass fragments excavated at Saint-Jean-des-Vignes were selected

for chemical analysis and examined microscopically. Most were chosen because they were typical of the colors, appearances, types of grozing, and states of weathering found among the group as a whole, but a few other fragments were selected specifically because they seemed to be atypical.

Portions of the fragments were cleaned with an air abrasive cleaner to remove the weathering products. Then the fragments were scribed, and small samples were snapped off. The samples were analyzed by Dr. Brandt A. Rising of Umpire and Control Services, now a section of Ledoux & Company, located in Teaneck, New Jersey. Dr. Rising used inductively coupled plasma spectroscopy (ICP) for the major and minor oxides and optical emission spectroscopy (OES) for trace elements. Silica was estimated by difference. The Museum's reference glasses A, B, C, and D were used for calibration.<sup>14</sup> No list of sample descriptions is included here, but the section titled "Tabulation of Findings" contains the relevant descriptive information.

The data are reported in Table 9 at the end of this article. Following our customary practice, they are accompanied by reduced compositions, that is, the seven major and minor oxides normalized to 100.00 percent.<sup>15</sup> In reduced compositions, the oxides are designated by asterisks.

Table 2 shows that of the 76 fragments analyzed, 58 are potash-lime glasses ( $K_2O:CaO:SiO_2$ ), 13 are soda-limes ( $Na_2O:CaO:SiO_2$ ), and five are mixed-alkalis ( $Na_2O, K_2O:CaO:SiO_2$ ).

14. Robert H. Brill, *Chemical Analyses of Early Glasses*, v. 1, *Catalogue of Samples*, and v. 2, *Tables of Analyses*, Corning: The Corning Museum of Glass, 1999. For the analytical procedures and reference glasses, see v. 2, pp. 529–544. For further information on the reference glasses, see R. H. Brill, "Interlaboratory Comparison Experiments on the Analysis of Ancient Glass," *Comptes rendus: VII<sup>e</sup> Congrès International du Verre, Bruxelles, 28 juin–3 juillet 1965*, Section B, Paper no. 226, pp. 226.1–226.4; and *idem*, "A Chemical-Analytical Round-Robin on Four Synthetic Ancient Glasses," *International Congress on Glass, Versailles, Sept.–Oct. 1971, Artistic and Historical Communications*, Paris: L'Institut du Verre, 1972, pp. 93–110.

15. Phosphorus ( $P_2O_5$ ) was not included in the normalization.



TABLE 2

## Saint-Jean-des-Vignes Families of Glasses

Potash-lime glasses $K_2O:CaO:SiO_2$	58
Soda-lime glasses $Na_2O:CaO:SiO_2$	13
Mixed-alkalis $(Na_2O,K_2O):CaO:SiO_2$	5
Total	76

These are three distinctly different chemical families of glasses.

The data were first surveyed by plotting several types of graphs of the various major and minor oxides, and then certain mathematical calculations were applied.

*Graphical Inspections*

Graphs of the lime versus potash ( $CaO^*$  vs.  $K_2O^*$ ) and phosphorus versus magnesia ( $P_2O_5$  vs.  $MgO^*$ ) proved especially useful for classifying the glasses, although several other plots can

also be used for the same purpose. The graphs revealed that among the 58 potash-lime glasses, there are three distinguishable subgroups. These have been arbitrarily labeled Types I, II, and III. (The designations are not related to any similarly named designations in other studies.)

Figure 1 shows the lime versus potash data. The following observations can be made:

1. The group at the far left contains the 13 soda-lime glasses.

2. The five points marked "Mx" are the mixed-alkali glasses.

3. The 13 points in the upper left have low potassium but very high lime. That is our Type I.

4. Toward the right are two other groups that are distinguishable from each other. They are our Types II and III.

Figure 2 shows the phosphorus plotted against the magnesia. The following observations can be made:

1. The three ellipses here set off the same three groups of samples as are enclosed in the three ellipses on the first graph. Therefore, on the basis of these four oxides, the 58 potash glasses can be separated into three distinct compositional subgroups: Types I, II, and III. Although not shown here, in a plot of iron oxide

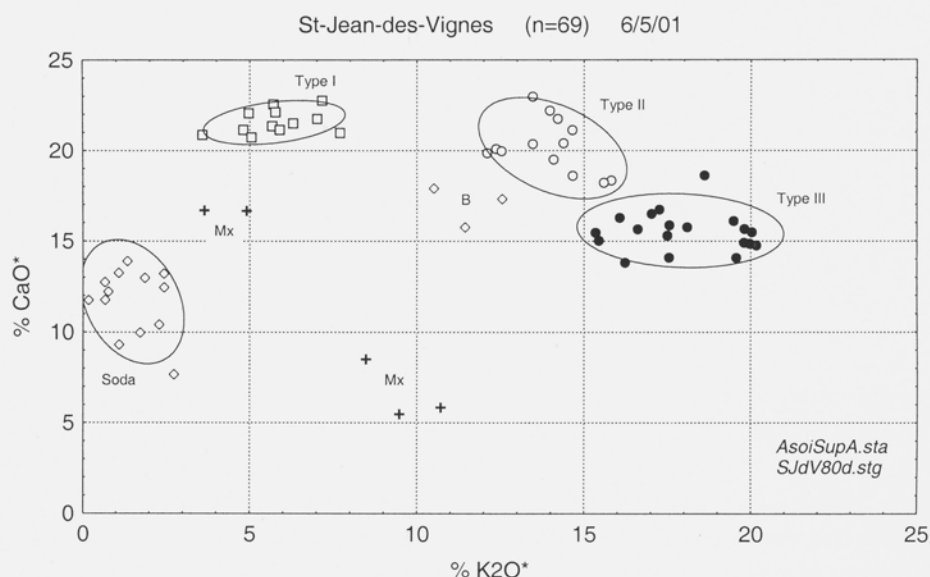


FIG. 1. Graph of lime vs. potash for Saint-Jean-des-Vignes glasses.

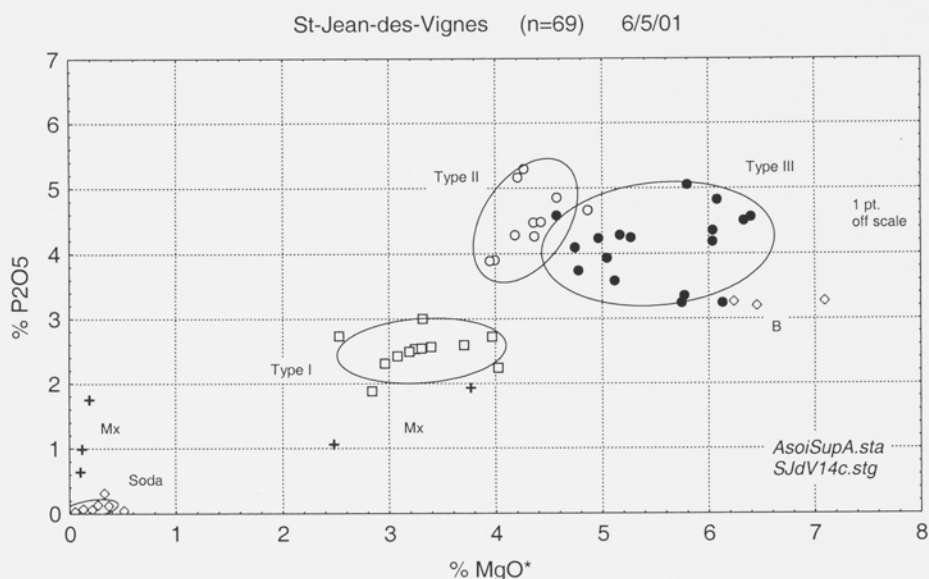


FIG. 2. Graph of phosphorus vs. magnesia for Saint-Jean-des-Vignes glasses.

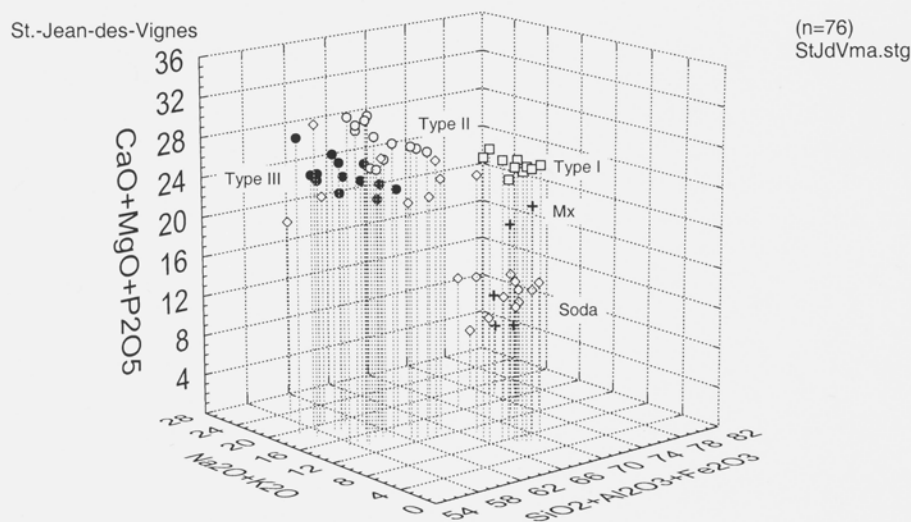


FIG. 3. Three-dimensional graph of data for Saint-Jean-des-Vignes glasses.

versus alumina ( $\text{Fe}_2\text{O}_3^*$  vs.  $\text{Al}_2\text{O}_3^*$ ), Type I differs from Types II and III, but Types II and III overlap each other.

2. There are three other samples that are closely related to one another, but they do not fit inside any of the ellipses.

3. On the basis of the graphs, and also considering their low iron and aluminum contents,

three of the mixed-alkali glasses (numbers 8122, 8125, and 8138) are thought to be relatively modern. The other two mixed-alkali glasses could be older. (Number 8175 actually came from Soissons Cathedral. It was analyzed inadvertently.)

4. The soda glasses are once again widely separated from the potash glasses.

For readers who are interested in methods of expressing analytical data graphically, we have included the three-dimensional plot in Figure 3. Eight major and minor oxides have been combined into three variables. They are grouped according to their glassmaking functions or common chemical affiliations. The three compositional types are readily apparent.

Readers who are familiar with the chemistry of early stained glass windows will recall that most of those glasses are potash-lime-silica glasses. For that reason, we will concentrate on the 58 potash glasses from Saint-Jean-des-Vignes in the following discussion.

The triangular diagram in Figure 4 presents the data for Types I, II, and III glasses in a still different manner. The graph shows a ternary plot of the potash ( $K_2O^*$ ), lime ( $CaO^*$ ), and silica ( $SiO_2^*$ ) values renormalized to 100.00 percent. Ternary graphs of this sort are often useful to glass scientists studying the physical properties of glass systems.<sup>16</sup> In this case, the diagram is useful for illustrating the differences in the three compositional types of glasses in terms of their major components.

The three types can also be characterized as shown in Table 3, although the ranges of the oxides stated there are only approximate. Eleven fragments are either borderline fits or do not fit clearly into any of the three types derived from the inspection of the graphs. On the graphs, they are either dispersed intermediately among the three types, or they are outliers. In effect, this means that about 20 percent of the potash glasses are left unaccounted for by this classification.

Presumably, the differences in the three types of glasses can be attributed to their having been made from different batch materials or by following different recipes. The differences could stem from a variety of factors. These include the sources and types of plant ashes used as alkali, the sources of silica, the methods of preparation or purification of the batch materials, separate additions of lime or bone ash, the mixing of different proportions of batch materials, and the inclusion of recycled cullet. This, in turn, raises the question of whether these three types of

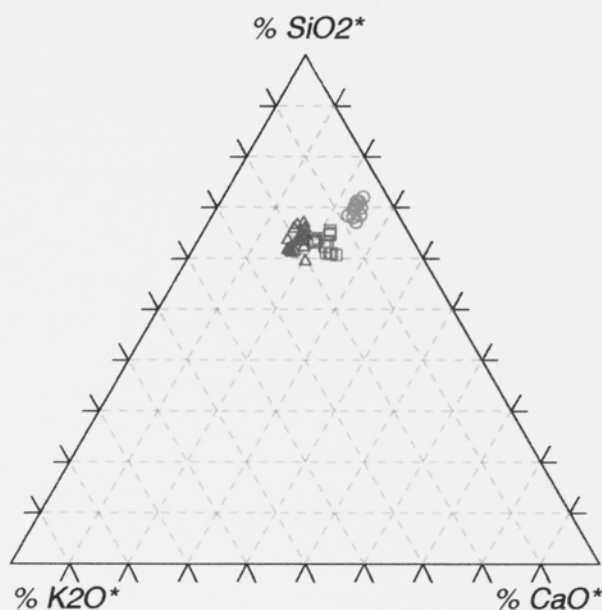


FIG. 4. Ternary diagram showing Types I, II, and III of Saint-Jean-des-Vignes glasses. Data for the three main components have been renormalized to 100.00 percent.

TABLE 3

Classification of Potash Glasses  
from Saint-Jean-des-Vignes

	% $K_2O^*$	% $CaO^*$	% $MgO^*$	% $P_2O_5$
Type I (n=13)	3.5–8	20–23	2.5–4.2	2–3
Type II (n=13)	12–16	18–23	3.8–4.8	3.6–5.4
Type III (n=21)	15–21	13–17	4.4–6.6	3.2–5.0
Borderline or unclassified (n=11)				
Total = 58				

16. These data, like all of the data in this article, are expressed as weight percentages of the oxides, not mole percentages.

glasses were made in different places and/or at different times. Most likely, they were. Now that chemical differences have been uncovered among the samples, the excavation data should be reviewed to see if they reveal any correlations with the chemical typology.

Following the original *a priori* classifications based on visual examinations, the observational types are distributed within the three chemical types as follows:

1. Type I consists of fragments that had originally been described as Grisaille B, along with four of the atypical colorless glasses.

2. Type II consists of most of the Grisaille A fragments and five of the blue glasses.

3. Type III consists of most of the ruby fragments and an assortment of other colors, as well as two of the Grisaille A fragments.

One finding is immediately clear: the weathering states, which were among the original criteria used for sorting the fragments, are consistent with the analytical data.<sup>17</sup> The 13 soda-lime glasses and the five mixed-alkali glasses are all noticeably less weathered than the potash glasses. Moreover, the Type I potash glasses (those with very low alkali and very high lime) are only lightly or moderately weathered, whereas the glasses of Types II and III—with their greater potash levels—are heavily weathered. All of these findings are consistent with our extensive (but largely unpublished) observations regarding the relative durabilities of these chemical types of medieval glasses.<sup>18</sup> Of course, if any fragments had been buried for significantly dif-

ferent lengths of time, that could have had some effect on the relative extents of weathering, as could localized variations in burial environments. (For example, fragments buried in close proximity to a latrine might be expected to have weathered somewhat more rapidly.) However, in the case of the Saint-Jean-des-Vignes glasses, we believe that chemical composition was the overall rate-controlling factor.<sup>19</sup>

### *Mathematical Treatment of the Data*

Two other questions arise. How do the compositions of the Saint-Jean-des-Vignes glasses compare with those of stained glasses<sup>20</sup> from other sites? Do such comparisons offer clues regarding the chronology of the excavated glasses or suggest geographical connections with glasses from elsewhere? In a broader sense, one wonders to what extent medieval window glasses in general can be classified geographically and/or chronologically according to their chemical compositions. This is a very complicated subject because of the huge number of existing windows and because of the paucity of representative analytical data.

To answer these questions, one ideally should have at hand a comprehensive library of analyses of glasses representative of those made in all of the major manufacturing centers over a wide span of dates. To our knowledge, nothing approaching such a body of data exists, although there are data scattered throughout the literature. It would certainly be worthwhile for some-

17. For our descriptions of weathering and colors, see Brill, *Chemical Analyses* [note 14], v. 1, pp. 15–18. Also, we use the term “ruby” for red transparent glasses colored with colloidal copper and/or cuprous oxide.

18. The results of a few weathering tests on experimental glasses replicating medieval stained glass compositions are reported in R. H. Brill, “Crizzling—A Problem in Glass Conservation,” *Conservation in Archaeology and the Applied Arts, Stockholm Congress*, London: The International Institute for Conservation of Historic and Artistic Works, 1975, pp. 121–134. See also *idem*, “Corrosion and Conservation,” 8<sup>e</sup> *Colloque du Corpus Vitrearum Medii Aevi: Compte rendu* (York, Cambridge, and Canterbury, September 25–October 1, 1972), [Marne, France]: Laboratoire de Recherche des Monuments Historiques, 1972, pp. 21–22.

19. The factors affecting the nature and extent of weathering were summarized in a recent lecture. They are: intrinsic properties (chemical composition, surface flaws, thermal history, heterogeneity, and surface decorations) and environmental conditions (presence of moisture, time of exposure, pH and other chemical factors, temperature, and microorganisms). See R. H. Brill, “The Morphology of Weathering on Historical Glasses,” presented at “The Surface: A Bug in New and Old Glasses,” GS-Conference, San Servolo, Venice, November 6, 2000.

20. Unlike some authors, we do not object to the use of the term “stained glass” to signify colored glass, and, indeed, consider the term “pot metal” to be both unnecessary and potentially misleading.

one to compile all of the existing reliable analyses of stained glasses and create such a library. The authors would heartily encourage such an effort, perhaps on a collaborative basis of interested parties.<sup>21</sup> For the time being, however, the best we can do here is work on the basis of those data that are readily available to us, namely, the analyses we ourselves have carried out.

In any event, when dealing with large numbers of analyses, it becomes helpful, perhaps imperative, to treat the data by multivariate statistical methods.

Our data consist of quantitative analyses of 263 stained glasses from 32 sites in eight countries.<sup>22</sup> (These include Types I, II, and III identified above as representing the Saint-Jean-des-Vignes finds.) The sites were arbitrarily designated beforehand as English, French, Germanic, and Mediterranean (the latter includes Italian and Iberian windows). The data set contains only potash glasses; soda glasses and mixed-alkalis are not included.

We performed two types of statistical calculations: a principal components analysis (PCA) and a cluster analysis.<sup>23</sup> It must be emphasized that these calculations are only exploratory in nature. Instead of dealing with 263 individual analyses, we employed 32 mean compositions of groups of glasses from the different sites.<sup>24</sup>

We determined that the data for the eight major and minor oxides we routinely deal with for potash-based stained glasses can be reduced mathematically to two principal components that involve mainly  $K_2O^*$ ,  $CaO^*$ ,  $MgO^*$ , and

TABLE 4  
Principal Components Analysis

Variable	PC1	PC2	PC3	PC4
CaO*	-0.108	0.905	-0.410	-0.017
K <sub>2</sub> O*	0.988	0.059	-0.126	-0.066
MgO*	-0.023	-0.297	-0.677	0.673
P <sub>2</sub> O <sub>5</sub>	-0.107	-0.297	-0.598	-0.737
Cumulative variability	68.2%	95.0%	98.7%	100.0%

$P_2O_5$ . These principal components are mathematical functions that account for about 95 percent of the total variability in the data.<sup>25</sup> The results of the PCA calculation are reported in Table 4. It can be seen there that the first principal component depends primarily on the potash value, while the second depends primarily on the lime value. The magnesia and phosphorus values do not come into play until one reaches the third and fourth principal components, which account for less than 5.0 percent of the total variability in the data.

Next, several cluster analyses were performed by assigning different starting parameters for the computations. Each computation yielded a different result. In the end, it was decided that one particularly useful and informative analysis was that which separated the glasses from the 32 sites into seven clusters, using the same four oxides listed in Table 4.<sup>26</sup>

21. This might be an appropriate undertaking for the various Technical Committees of the *Corpus Vitrearum Medii Aevi*.

22. R. H. Brill, *Chemical Analyses* [note 14], vv. 1 and 2, sections XI D.-XI AP. and XI AS. For some of the data included here, see also R. H. Brill and S. Weintraub, "Chemical Analyses of Some Stained Glass Windows in León Cathedral," *Proceedings of the XVIth International Congress on Glass*, v. 7, Madrid, 1992, pp. 143-148; and R. H. Brill, "Composición química de algunos vidrios de la Catedral de León," *Conservación de vidrieras históricas. Análisis y diagnóstico de su deterioro. Restauración*, Los Angeles: The Getty Conservation Institute, 1997, pp. 114-131. (An English version is available from the author.)

23. Minitab (Release 13) software was used for the computations.

24. In certain calculations, we actually used 296 samples.

25. The inclusion of  $Na_2O^*$ ,  $Fe_2O_3^*$ , and  $Al_2O_3^*$  in trial calculations did not have much effect on the results. Therefore, for the sake of simplifying the procedure, they were not included in the final calculation.  $SiO_2^*$  was excluded for similar reasons, as well as for the fact that because it was calculated by difference in the original analyses, it also included unknown levels of anions.

26. Selecting a greater number of clusters at the outset of the calculation tended to isolate individual outlying samples rather than to separate out groups of samples. Somewhat surprisingly, using a greater or smaller number of oxides did not affect the makeup of the resulting clusters to any great extent.



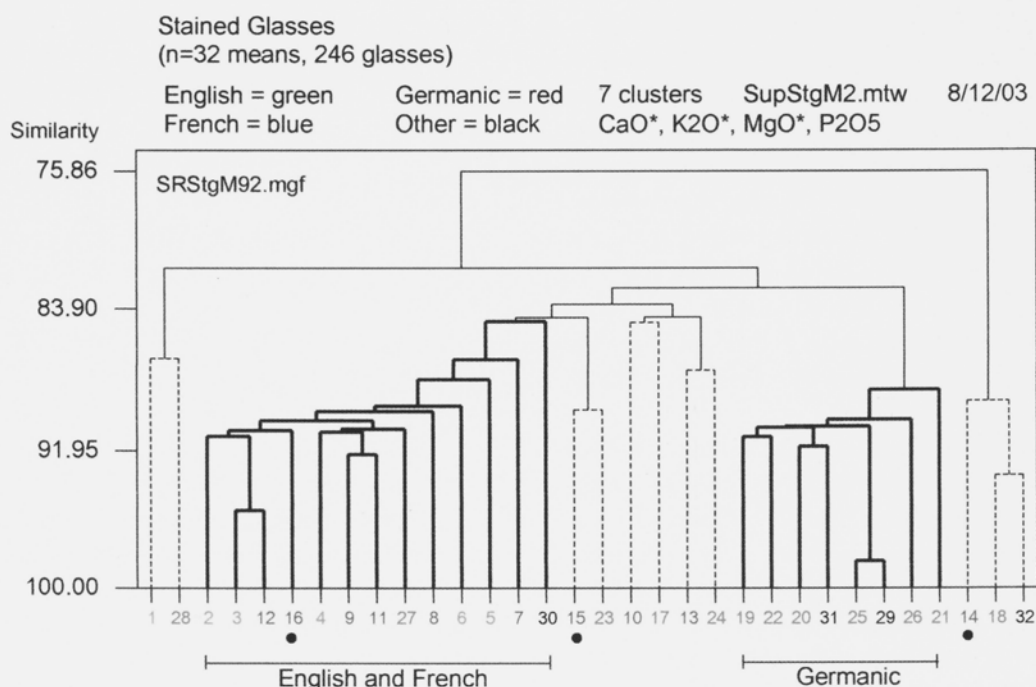


FIG. 5. Dendrogram resulting from cluster analysis of 32 groups of medieval stained glasses. Data were introduced as mean values of four oxides (K<sub>2</sub>O\*, CaO\*, MgO\*, and P<sub>2</sub>O<sub>5</sub>) for each group. The groups within each of the seven clusters are relatively similar to one another chemically, and they are unlike the glasses within other clusters. In all, 246 samples were included in the calculation. The scale along the bottom identifies the groups contained in the various clusters. The green numbers indicate groups from England, blue are groups from France, red are Germanic groups, and black are Mediterranean groups. The Saint-Jean-des-Vignes Types I, II, and III are numbers 14, 15, and 16 respectively. Note that the spread among the Saint-Jean glasses is almost as great as that among the array as a whole, indicating that the three types were made at different places and/or times.

The resulting dendrogram is shown in Figure 5. For those who are not familiar with such diagrams, the most important feature of the one shown here is that the mean compositions of the glasses from the 32 sites have been grouped mathematically into seven clusters of sites based on similarities in their chemical compositions. The sites within each cluster are relatively similar to one another, while those in different clusters are dissimilar. Furthermore, the clusters appear to have some geographical basis. The numbers along the bottom axis of the diagram show which sites are clustered together and how they are separated from the others.<sup>27</sup> Reading from left to right, we can see that the English and French glasses are relatively similar and

overlap one another to some extent. The Germanic glasses fall toward the right. The other clusters contain outlying sites or those that are intermediate among larger clusters.

27. The sites, along with the dates provided by the sample donors, are as follows:

1. Glastonbury, ninth–10th centuries (?).
2. Canterbury I, 1200–1225.
3. Canterbury II, 1200–1225.
4. Coventry, 13th–14th centuries.
5. York, possibly 14th century.
6. Winchester, about 1400.
7. Saint-Maur-des-Fosses, late 13th century.
8. Chartres, about 1225.
9. Saint-Victor (Marseilles), 13th century.
10. Avignon, 14th century.
11. Rouen, 14th century.

Interestingly, the three types of glasses from Saint-Jean-des-Vignes (numbers 14, 15, and 16) are spread out considerably along the bottom of the dendrogram. This means that they appear to differ from one another about as much as stained glasses as a whole differ from one another. This is a clear indication that the glasses of Types I, II, and III were made in different places and/or at different times. Therefore, they would seem to represent different glazing campaigns. But one has to be careful because one of these types (III) contains all of the ruby glasses that were assigned to the various types. (Three rubies were not classified.) Inasmuch as ruby glasses were relatively difficult to make, it could be that, although the rubies were made somewhere else, they could still have been contemporaneous with one of the other two types. (The soda and mixed-alkali glasses, of course, represent still different campaigns, with the soda glasses probably being later than the potash glasses.)

#### A BROADER VIEW

How do the Saint-Jean-des-Vignes glasses fit into the overall picture of medieval stained glass compositions? Specifically, do the data offer clues as to the chronology of the excavated glasses, or do they suggest geographical connections with glasses from elsewhere?

Concentrating on the graphical approach, Figures 6 and 7 show data for 296 of the same potash stained glasses that were used above. (Again, they represent 32 sites in eight countries,

and they include Types I, II, and III from Saint-Jean-des-Vignes.)

The graphs are obviously too complicated to work with. They also raise the question of whether or not discrete "chemical typologies" really exist within the compositions of medieval stained glasses, or whether the compositions constitute a broad continuum of compositions—something like a continuum of many overlapping types.<sup>28</sup> Figure 8, another triangular diagram, shows the same array of glasses. Glass scientists might be interested in comparing the distribution of these points to the glass-forming region of the phase diagram for the  $K_2O:CaO:SiO_2$  system.

By separating the data for the glasses from these sites, and by replotting them on more simplified graphs (not shown here), it was possible, although tedious, to make some comparisons with the Saint-Jean-des-Vignes glasses. The same four oxides used for Figures 1 and 2 were used ( $CaO^*$  versus  $K_2O^*$  and  $P_2O_5$  versus  $MgO^*$ ). The process was somewhat subjective, but it did serve to place the Saint-Jean glasses within a broader, though tentative, context. If one compares the relationships between the sites, they are in good agreement with the groupings in the dendrogram discussed above.

Table 5 lists sites from which we found one or more examples of glasses that match the Saint-Jean-des-Vignes glasses. They are divided arbitrarily into English, French, Germanic, and Mediterranean sites. Table 6 lists sites where no matches were found.

12. Saint-Denis, 12th century.
13. Pitcairn Collection, 12th century.
14. Saint-Jean-des-Vignes I.
15. Saint-Jean-des-Vignes II.
16. Saint-Jean-des-Vignes III.
17. Augsburg, 1130 (Prophets) and 1350.
18. Naumburg, 14th–15th centuries.
19. Magdeburg, not stated.
20. Erfurt, 1300–1325.
21. Nürnberg, 14th–17th centuries.
22. Ulm, about 1400.
23. Speyer, about 1170.

24. Lorsch, not stated.
25. Regensburg, about 1300.
26. St. Leonhard, about 1340.
27. Austria, about 1330 and 15th century.
28. Bern, 15th–16th centuries.
29. Florence, 14th–16th centuries.
30. Leon I, 13th century.
31. Leon II, 15th century.
32. Batalha, 15th–16th centuries.

28. More refined multivariate statistical computations have been performed using all of our stained glass data. The findings will be published elsewhere in the future.

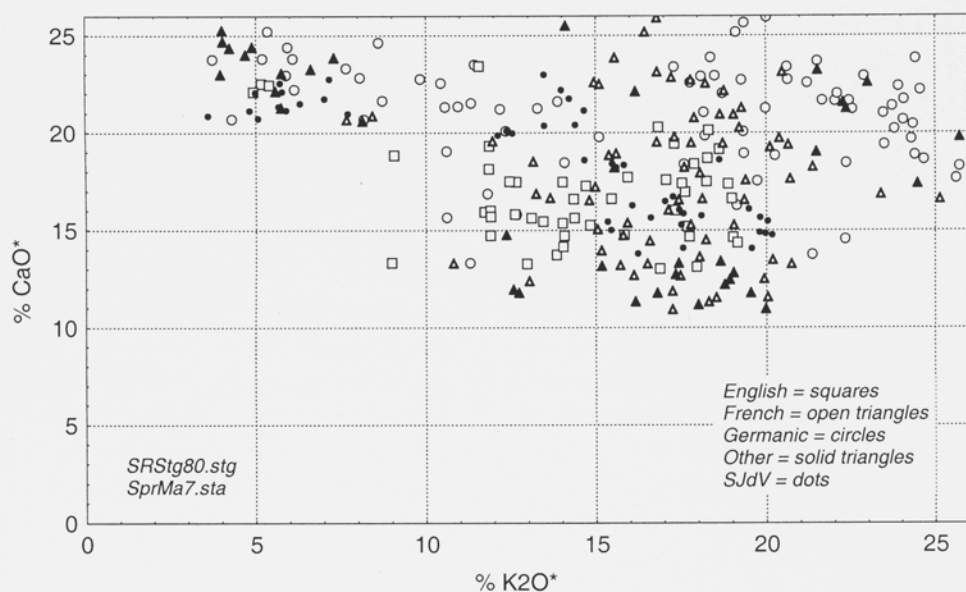


FIG. 6. Graph of lime vs. potash for 296 samples of medieval stained glasses, including Saint-Jean-des-Vignes glasses, illustrating their wide range of chemical compositions.

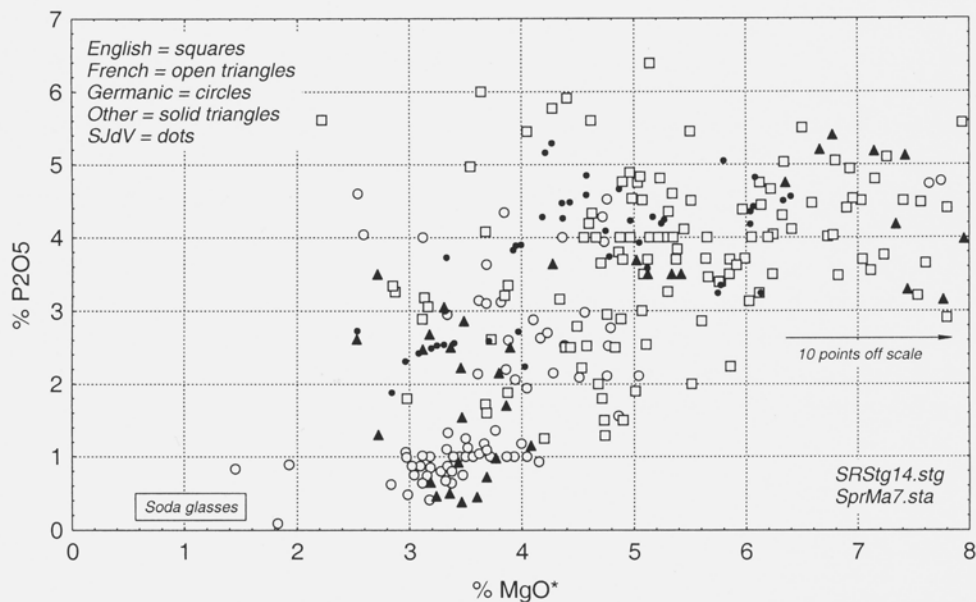


FIG. 7. Graph of phosphorus vs. magnesia for 296 medieval stained glasses. The squares at  $P_2O_5 = 4.0$  are estimated values. The box at the lower left is for soda glasses.

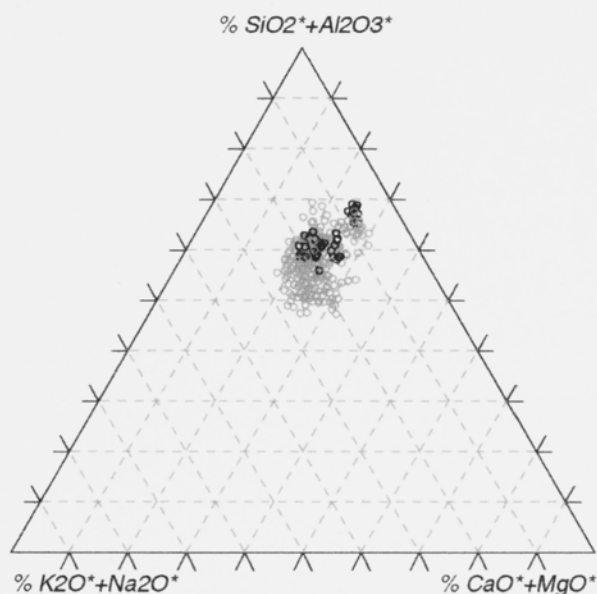


FIG. 8. Ternary diagram of data for 296 medieval stained glasses. The three vertices mark 100% levels for selected sums of major and minor components of potash-lime-silica glasses. The black circles are for the Saint-Jean-des-Vignes glasses.

The map in Figure 9 shows the sites where one or more examples matching the Saint-Jean-des-Vignes Types I, II, and III were found. Of 263 potash-lime glasses or mixed alkalis from the other places, 63 to 75 glasses were matches or possible matches. (The number obviously varies according to how strictly one interprets the compositional limits.) Overall, then, about one-fourth of the glasses from the other sites fit into the Saint-Jean Types I, II, and III. The open circles mark sites where no matches were found.

This was not a very rigorous process because it was done graphically and also because the comparative data available did not constitute a sound basis for describing the entire compositional range of medieval stained glasses. A total of 263 samples is nothing more than a start toward developing a picture of medieval stained glass compositions. Nonetheless, the findings are useful as guidelines for anticipating what might result from more comprehensive and systematic studies in the future. The following tentative observations can be made regarding the Saint-Jean-des-Vignes glasses:

1. The preponderance of matches for Type III, with its high potash and moderately high lime, favors a resemblance to glasses from several sites

in France and England. The dates of the 33–45 matching glasses from France and England, based on information provided by their donors, range from about 1200 to about 1400. (The cluster analysis placed the Type III glasses toward the left of the dendrogram, along with glasses from several French and English sites. They include Canterbury, Coventry, York, Winchester, Saint-Maur-des-Fosses, Chartres, Saint-Victor, Rouen, and Saint-Denis, as well as some windows from Austria and Leon.)

2. Type II appears to be the least common of the three types, judging from the fact that only four parallels were found. This is the type with moderate potash and very high lime. All four parallels are French, and they date from about 1280 to about 1520. (The cluster analysis placed Type II near the center of the dendrogram, along with glass from a single German site, Speyer. However, the four French sites were not included in the data used for the cluster analysis.)

3. Type I, the unusual glasses with very low potash and very high lime, has parallels in all four of the geographical regions considered. The 23 individual parallels range in date between about 1250 and the 15th–16th centuries. (The cluster analysis placed Type I at the far right of the dendrogram, along with glass from the Ger-

TABLE 5

# Sites Where Matches Were Found for Saint-Jean-des-Vignes Glasses

Based on CaO\* vs. K<sub>2</sub>O\* and P<sub>2</sub>O<sub>5</sub> vs. MgO\* plots.

Potash and mixed-alkali glasses only.

(N) = total number of glasses compared.

	<i>Type I</i> (No. of Samples)	<i>Type II</i> (No. of Samples)	<i>Type III</i> (No. of Samples)
English (N=51) [3 soda glasses excluded]	Glastonbury (4 of 10)		Canterbury (3–6 of 13) Coventry (6–10 of 10) Winchester (2–4 of 5) York (2 of 10)
French (N=88) [13 soda glasses excluded]	Psalmody (2 of 2)	Amiens (2 of 3) Rouen (1 of 9) Aube (1 of 2)	Saint-Maur-des-Fosses (7–9 of 19) Rouen (2 of 9) Saint-Victor (4 of 8) Chartres (2 of 5) Amiens, Evreux, Brennelis, Le Mans, Normandy (5–6 of 9) Saint-Denis (3 of 6)
Germanic (N=80) [1 soda glass excluded]	Magdeburg (3 of 5) Erfurt (1 of 7) Bern (1 of 10)		
Mediterranean (N=44) [4 soda glasses excluded]	Batalha (9 of 11) Florence (3 of 6)		
Sum = 263 [21 soda glasses excluded]	23 matches	4 matches	36–48 matches



TABLE 6

Sites Where No Matches Were Found

Potash and mixed-alkali glasses only.

(n) = total number of glasses in list.

(N) = number including nonmatches in Table 3.

English (N=3+22 = 25) [no soda glasses]	Norwich, Dorchester (n=3)
French (N=22+37 = 59) [7 soda glasses]	Rougiers, Avignon, Mont-Saint-Michel, Pitcairn Collection, Bourges, other (n=29)
Germanic (N=58+17 = 75) [1 soda glass]	Augsburg, Naumburg, Halberstadt, Nürnberg, Ulm, Speyer, Oppenheim, Schulpforta, Kloster Lorsch, Freiburg, Goslar, Leonhard, Rust (n=59)
Mediterranean (N=27+5 = 32) [2 soda glasses]	Milan, Pavia, Leon (n=29)

Total nonmatches = 191 glasses (as opposed to maximum of 72 matches)

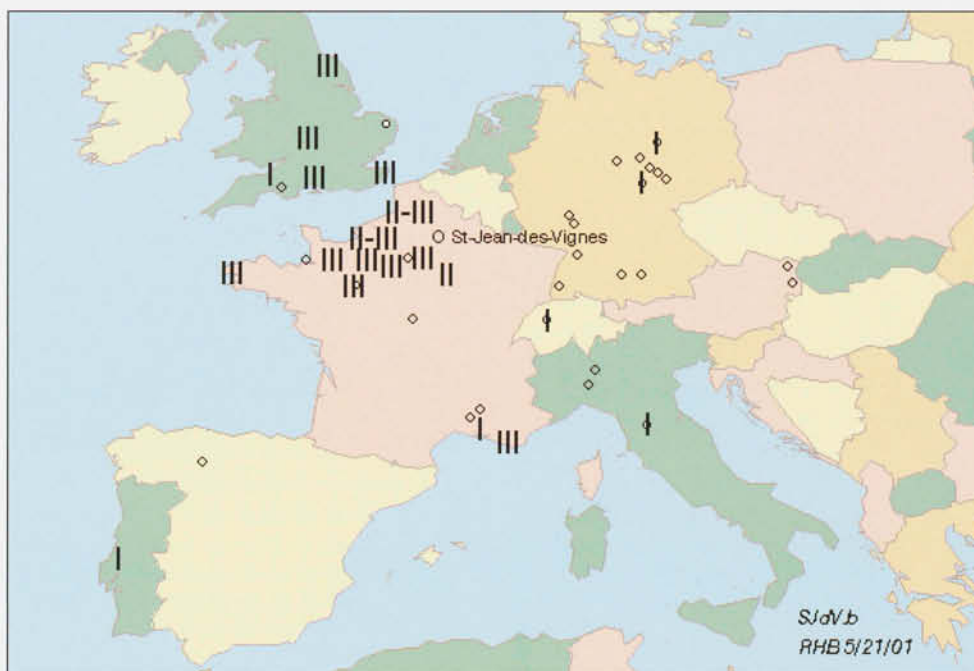


FIG. 9. Map showing locations where glasses matching the Saint-Jean-des-Vignes Types I, II, and III have been found. Open circles mark sites where no matches were found.

man site of Naumburg and the site of Batalha in Portugal.)

4. For the most part, the findings of the multivariate statistical approach are in line with the findings listed here that were based on inspections of graphs. Logically, this should be the case, but it is reassuring that it actually turned out to be generally true.

Comparing the graphical observations on the Saint-Jean-des-Vignes glasses with their original typological sorting, we offer the following remarks, as summarized in Table 7.

1. The 13 Type I fragments, consisting of the Grisaille B fragments and four atypical fragments, are of a compositional type of glass that is rather broadly distributed both chronologically and geographically. Except for a glass from Winchester, the matches come mainly from the east and south.

2. The 13 Type II fragments, consisting of Grisaille A and five blue glasses, are of a less common compositional type known from France over a rather long period of time.<sup>29</sup>

29. Our Types II and III bear some chemical resemblances to compositional groups defined by Barrera and Velde for vessel glasses excavated in France. When the  $(\text{CaO}^*)/(\text{CaO}^* + \text{K}_2\text{O}^*)$  ratios for the Saint-Jean-des-Vignes Type II glasses are plotted versus the  $\text{Na}_2\text{O}^*$  values, the points become superimposed on Barrera and Velde's Type A, Period II glasses. Our Type III glasses are a borderline match. This indicates a similarity between the Saint-Jean Types II and III stained glass window fragments and Barrera and Velde's vessel glasses that date from 1200 to 1450. The latter were found in northeastern France. The three sites mentioned by Barrera and Velde are Châlons-sur-Marne, Metz, and Argonne. All of these sites are within about 125 miles of Soissons. We emphasize, however, that these coincidences hold only for that particular graph. (Their only other graph shows the  $\text{MgO}$  versus  $\text{Na}_2\text{O}$ , and there our magnesia values are generally greater.) See J. Barrera and B. Velde, "A Study of French Medieval Glass Composition," *Journal of Glass Studies*, v. 31, 1989, pp. 48–54; and Philippe Marquis and others, "Late Medieval and Renaissance Glassware from the rue des Lombards, Paris," *Journal of Glass Studies*, v. 42, 2000, pp. 97–112.

30. We cannot pass over the soda glasses without some comment. In general, they do not form an especially tight chemical group. Also, there are two fragments that deserve to be singled out. Both are dark blue glasses colored with copper and cobalt, and both contain minor levels of lead ( $\text{PbO}$ ). Number 8127 is unusual in that its analysis shows that it contains 0.50 percent silver (as the oxide  $\text{Ag}_2\text{O}$ ). Number 8126 is unusual in that it contains 0.30 percent antimony (as the oxide  $\text{Sb}_2\text{O}_3$ ). We have seen antimony in only a very few medieval stained glasses. They are invariably dark blue soda-limes containing cobalt, and they

3. The 21 Type III fragments, consisting of most of the ruby fragments, along with an assortment of other colors and two Grisaille A fragments, are of a compositional type found in both French and English settings dated between about 1200 and about 1400.

4. Eleven of the potash glasses are left unaccounted for by this reckoning. Also, the 13 soda-lime glasses, representing about 17 percent of the 76 samples analyzed, should be dealt with similarly.<sup>30</sup> We are inclined to believe that they are either later than the potash glasses, or, if they are contemporaneous with them, that the soda glasses might have been made in the south, closer to sources of barilla.<sup>31</sup>

5. Two of the five mixed-alkali glasses are probably old, but they may not be window glass, while the other three examples are believed to be relatively modern.

6. It appears that the various compositional types are rather long-lived, and that the differences in composition are more a matter of geography than of date.

date from the 12th century. They occur in windows where they are surrounded by other colors of glass, all of which are ordinary potash glasses of the time. The blue soda glasses are markedly less weathered than the glasses of other colors. We believe that the dark blue soda glasses (dubbed "soda DBTs") were made of glass imported especially for the purpose from easterly or southerly sources where soda glasses were still routinely used. (We have in mind the Byzantine world or Italy.) They may have been imported because local sources of cobalt colorants were not yet being exploited in western Europe. After the 12th century, as far as we know, dark blue window glasses were usually potash glasses, just like all of the other colors. See R. H. Brill, "Chemical Analyses of the Zeyrek Çamii and Kariye Çamii Glasses," to appear in the proceedings of the Workshop on Byzantine Glass held at Dumbarton Oaks on November 16, 2002 (forthcoming); R. H. Brill and I. Lynus Barnes, "The Flight into Egypt, from the Infancy of Christ Window (?): Some Chemical Notes," in S. M. Crosby and others, *The Royal Abbey of Saint-Denis in the Time of Abbot Suger (1122–1151)*, New York: The Metropolitan Museum of Art, 1981, p. 81; R. H. Brill, "Chemical Analyses of Some Glasses from Jarrow and Wearmouth," in Rosemary Cramp's forthcoming publication on glass from Jarrow and Wearmouth; and Brill, *Chemical Analyses* [note 14], v. 1, pp. 118–123 and 131–132, and v. 2, pp. 261, 266, 272, 277, 280, and 312.

31. We have analyzed some stained glass window fragments from southern France that are soda-based glasses. These include some 13th-century glasses from Psalmody, a single fragment from Rougiers (about 1400), and one from Avignon (14th century).

TABLE 7

## Saint-Jean-des-Vignes Glasses

	<i>Type I</i>	<i>Type II</i>	<i>Type III</i>
Chemical Type	Very low K <sub>2</sub> O Very high CaO	Moderate K <sub>2</sub> O Very high CaO	High K <sub>2</sub> O Moderately high CaO
Number	13	13	21
Typology	9 Grisaille B, 4 atypical	8 Grisaille A, 5 blue	2 Grisaille A, 11 ruby, 5 blue, 1 purple, 2 amber
Geographical distribution	Broad, but mainly to the east and south	France	England, France
Date	About 1250– 15th–16th centuries	About 1220– about 1520	About 1200– about 1400
Number of matches	23	4	33–45

7. The three types of potash glass apparently represent either two or three separate glazing campaigns.

#### SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

The original intent of this project was to assemble information from five diverse approaches to the study of glass: visual examinations, chemical analyses, archeological excavation records, historical documentation, and existing art-historical information gained from examinations of well-studied windows. To date, only the first two of these have been brought together.

The 76 analyzed fragments revealed four distinctly different chemical types of glass. There were three types of potash glasses and an assortment of soda glasses. All of the potash glasses are probably medieval, while the soda glasses are presumed to be of somewhat later date.

We believe that the three types of potash glasses from Saint-Jean-des-Vignes—which are the more interesting fragments—could very well have been made at different times and/or different places. Statistical calculations and graphical comparisons of the compositions of these glass-

es with window glasses from 32 other, widespread sites show some interesting similarities and differences. In particular, matches for the Saint-Jean potash compositions were found at several other sites, showing that the Saint-Jean compositions are not unique to that site. However, it would be premature to attempt to draw specific conclusions regarding the origins and dating of the Saint-Jean glasses solely on the basis of those comparisons.

It is also important to note that the variability among the three types of potash glasses from Saint-Jean is about as great as that among the glasses from the other 32 sites. Therefore, it seems reasonable to conclude from the Saint-Jean analyses (including those of the soda glasses) that the glasses there were produced in at least three, and possibly four, different glazing campaigns. However, because of the small number of fragments recovered, the glass from a single window could, theoretically, have constituted "a campaign."

The total area of all the excavated fragments from Saint-Jean was estimated to be about 1.6 square meters. Consequently, the fragments analyzed here are not necessarily representative of all the glass that might once have been in the

buildings. The small quantity of glass recovered also raises the question of what might have happened to all the other glass that is thought to have once existed at the site. One wonders if much of it might have been gathered centuries ago for recycling.

The chemical typology correlates strongly with the weathering characteristics observed before the analyses were done, and also, to a certain extent, with the thicknesses of the fragments. This reinforces the inference that the various chemical types of fragments were probably made at different times and/or different places.

One guiding principle in the scientific investigation of any sort of artifacts—including glass—is that, after obtaining the laboratory data, it is always advisable to re-examine the artifacts themselves. In many cases, one then sees the artifacts in a different light.

Eventually, the scientific results presented here must be correlated with the archeological context and with an art-historical study of the glass fragments.<sup>32</sup> Meanwhile, the analyses reported here are valuable not only because they tell us something about the Saint-Jean fragments in particular, but also because they tell us something about stained glasses in general. They provide a model and a starting point for studying glasses from other sites, and they illustrate the usefulness of analyzing relatively large numbers of carefully selected samples. This study also underscores the desirability of developing a systematic and comprehensive library of medieval stained glass compositions. Once such a library has been compiled, various multivariate statistical calculations can be applied that should lead to chemical classifications of medieval windows. Such classifications could be expected to

provide valuable supplementary information for archeological, art-historical, and documentary research. Needless to say, a reliable classification scheme would also greatly advance our understanding of the evolution of glass technology in medieval times.

## TABULATION OF FINDINGS

The concordances below (Table 8) summarize the chemical typologies, sample numbers, field numbers, and descriptive remarks (Field Assignments) for the 76 fragments analyzed. The descriptive information was extracted from field notes and laboratory notes recorded by the authors.

The extent of weathering is described as follows: W = heavily weathered, w = moderately weathered, s = slightly weathered, – = little or no weathering. The thickness of the glass (which is often quite uneven) is described as: "thin" (= ~1.5 mm), "medium" (~1.5–2.5 mm), or "thick" (= ~2.5 mm). The Grisaille A glasses are mostly pale greenish aqua; the Grisaille B are generally more nearly colorless; the Grisaille C are a rather strong bluish aqua. The date ranges refer to the dates of the glasses of each chemical type that came from sites other than Saint-Jean. The symbol "n" is the number of examples of each type that were found for Saint-Jean. The findspots of all fragments are recorded in our laboratory notebooks.

32. This study will appear as part of *Paradisus Clausalis, les fouilles du grand cloître de l'abbaye de Saint-Jean-des-Vignes, 1999–2001 et l'étude du mobilier provenant du site*, ed. Sheila Bonde and Clark Maines, a special number of the *Revue Archéologique de Picardie*.

## ADDENDUM

The analysis of sample 8192 (see Table 9) was completed while this article was in press. Therefore, it is not discussed in the text. The sample is from a thick, heavily weathered piece of grisaille glass in the lone intact panel recovered at the site (see note 13). The analysis shows that the glass belongs firmly to the Type II composition, which includes several examples of thick, heavily weathered Grisaille A glass.

TABLE 8  
Concordances

Type I  
About 1250–15th/16th Century  
Broad Range of Glass throughout Continent  
(n=13)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>	<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8111	Tr. 12 lot 83.L.135	Grisaille B s/thick	8159	Tr. 82.1 feature 3 layer 3 lot 1018	Ruby W/medium
8112	96 DZ DD, lot 833	Grisaille B W/medium	8169	Tr. 26 layer 001 lot 85.L.52	Figural roundel fragment s/medium
8113	Sacristy layer 002 lot 85.L.25	Grisaille B s/thick	8170	Tr. 12 level 002 S.83.14a–g	Painted and silver-stained s/thin
8114	Chapter room feature 8 lot 85.L.13	Grisaille B s/medium	8171	lot 85.L.223	Oak leaf roundel fragment w/thin
8115	Chapter room feature 1 lot 85.L.1	Grisaille B s/thin	8172	Tr. 99.68 feature 4 lot 114 S.99.1	Grisaille painted with linear and foliate design w/medium
8116	1951/52 grisaille green, unpainted	Grisaille B s/thin			
8117	Tr. Sacristy layer 002 lot 85.L.25	Grisaille B s/thin			
8118	Tr. 14 layer 4 lot 83.L.46	Grisaille B W/thin			



TABLE 8 (cont.)

## Concordances

## Type II

About 1220–About 1520

Characteristic of Glass in France over a Long Period of Time

(n=13)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>	<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8100	39 Tr. 19 N ext. lot 39:17 S.83.52	Grisaille A W/thick	8106	Tr. 17 layer 010 83.L.174	Grisaille A W/thick
8101	39 Tr. 19 N ext. lot 39:17 S.83.52	Grisaille A W/thick	8109	1951/52 painted grisaille	Grisaille A w/thick
8102	39 Tr. 19 N ext. lot 39:17 S.83.52	Grisaille A W/thick	8124	1951/52 blue, painted	Blue w
8103	Tr. 99.68 006, 130 S.99.10	Grisaille A W/thick	8130	Tr. 82-1 feature 3 layer 3 lot 1018	Blue w
8104	1951/52 unpainted grisaille	Grisaille A W/thick	8132	Tr. 13 layer 001 83.L.17	Blue W
8105	Tr. 15 layer 001 83.L.9	Grisaille A W/thick	8135	1951/52 blue	Blue w
			8136	1951/52 blue	Blue W

TABLE 8 (cont.)

## Concordances

## Type III

About 1200–About 1400

Characteristic of Glass in France and England

(n=21)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>	<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8107	Tr. 24 layer 001 84.L.2	Grisaille A W/thick	8149	1951/52	Ruby, striated W/thick
8108	Tr. 28 layers 006 & 007 85.L.153	Grisaille A W/thick	8150	1951/52	Ruby, striated W/thick
8123	1951/52 blue, painted	Blue w	8151	1951/52	Ruby, striated W/thick
8128	1994.51 layer 005	Blue w	8152	1951/52	Ruby, striated W/thick
8129	Tr. 24 feature 3 84.L.15	Blue W	8153	1951/52	Ruby, striated W/thick
8131	Tr. 60 zone E layer 012	Blue W	8154	1951/52	Ruby, striated W/thick
8134	1951/52 blue	Blue W	8155	1951/52	"Flesh" (pale pinkish amber) W/thick
8141	1951/52 purple	Purple W	8157	Tr. 24 feature 3 84.L.15	Ruby, striated w/thick
8144	Tr. 82-1 lot 1037 85.5.144	Amber w	8161	1951/52	Ruby, flashed W/thick
8147	1951/52 amber, painted	Amber W	8162	1951/52 painted	Ruby, striated W/thick
			8167	1994.51 layers 001 & 002	Ruby, striated W

TABLE 8 (cont.)

## Concordances

## Soda Glasses

Early Examples Occasionally Found in Italy; Became Ubiquitous  
toward the West after about the 16th Century

(In general, from Venice eastward, only soda glasses were made for use  
as windows, vessels, and mosaic tesserae)

(n=13)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>	<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8119	Tr. 89.05.36 feature 001 layer 002 lot 002	Grisaille C s/thick	8143	Tr. 96.DZ.DD lot 816	Amber ?
8120	Tr. 20 feature 3 83.L.107	Grisaille C s/thick	8148	Tr. 16 layer 2 83.L.24	Amber —
8121	Tr. 20 feature 3 83.L.107	Grisaille C —/thick	8163	Tr. 96.DZ.DD lot 833	Flashed ruby s/thick
8126	Tr. 1994.51 lot 005	Blue —	8164	Tr. 96.DZ.AA lot 830	Flashed ruby s/thick
8127	Tr. 1994.51 lot 002	Blue s or —	8165	Tr. 94.51 lot 005	Flashed ruby —
8140	Tr. 96.61c lot 103	Purple —	8166	Tr. 94.51 lots 001 & 002	Flashed ruby —/thick
8142	Tr. 1994.51 lot 005	Amber ?			

TABLE 8 (cont.)

## Concordances

Mixed-Alkali Glasses  
 Dating and Distribution Uncertain,  
 but Generally Less Common than Other Types  
 (n=5)  
 (\* = possibly late)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8122*	Tr. 96.DZ.DD lot 833	Blue s or –
8125*	83.L.107	Blue s or –
8138*	83.L.104	Blue s
8174	89.05.36 016 003	Aqua ?
8175	83.L.165	Aqua s or –

## Unclassified (Outliers or Intermediate)

(n=11)

(\* = fragment from Soissons Cathedral)

<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>	<i>Corning Number</i>	<i>SJdV Number</i>	<i>Field Assignment</i>
8110	85.L.25	Grisaille B W	8156	83.L.266	Ruby, striated W/thick
8133	1951/52 b	Blue w	8158	96.60 E.012	Ruby, striated W/thick
8137	1951/52 b	Blue W	8160	1951/52	Flashed ruby W/thick
8139	96.DZ.DD lot 816	Purple w	8168	84.L.15	Pale blue w
8145	1951/52	Amber w	8176*	SC (Barnes excavation)	Purple W
8146	1951/52	Amber w			

TABLE 9  
Chemical Analyses of Saint-Jean-des-Vignes Glasses

	8100	8101	8102	8103	8104	8105	8106	8107	8108	8109	8110	8111
SiO <sub>2</sub> d	52.50	55.59	53.00	55.90	52.85	52.86	56.04	58.15	55.30	56.70	60.20	59.07
Na <sub>2</sub> O	0.37	0.57	0.62	0.57	0.56	0.39	0.58	0.60	0.87	0.40	1.28	2.03
CaO	21.5	17.4	19.9	17.3	20.5	20.8	17.5	14.5	14.8	19.0	17.2	21.7
K <sub>2</sub> O	12.6	15.0	13.8	14.8	13.4	13.1	14.7	16.6	17.0	11.7	10.1	5.49
MgO	3.94	3.79	4.31	3.75	4.59	4.00	3.73	3.16	4.30	4.13	6.20	3.82
Al <sub>2</sub> O <sub>3</sub>	1.63	1.73	1.76	1.86	1.65	1.72	1.77	1.42	1.14	1.95	0.67	3.41
Fe <sub>2</sub> O <sub>3</sub>	1.03	0.79	0.78	0.78	0.72	0.85	0.72	0.45	0.57	0.71	0.43	0.71
TiO <sub>2</sub>	0.21	0.22	0.19	0.22	0.19	0.2	0.22	0.15	0.13	0.25	0.065	0.20
Sb <sub>2</sub> O <sub>5</sub>												
MnO	0.71	0.70	0.62	0.70	0.72	0.68	0.70	1.16	0.70	0.70	0.58	0.76
CuO	0.050	0.02	0.05	0.02	0.04	0.01	0.01	0.01	0.12	0.10	0.01	0.01
CoO												
SnO <sub>2</sub>		0.01	0.001	0.01			0.01		0.12	0.005		
Ag <sub>2</sub> O	0.005	0.001	0.001	0.001	0.001	0.005	0.001	0.001	0.001	0.001	0.001	0.001
PbO	0.20	0.20	0.02	0.11	0.01	0.005	0.11	0.005	0.29	0.02	0.005	0.005
BaO												
SrO												
Li <sub>2</sub> O												
Rb <sub>2</sub> O												
B <sub>2</sub> O <sub>3</sub>	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V <sub>2</sub> O <sub>5</sub>												
Cr <sub>2</sub> O <sub>3</sub>												
NiO												0.005
ZnO	0.065	0.051	0.077	0.069	0.081	0.062	0.053	0.039	0.055	0.050	0.039	0.046
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>												0.001
P <sub>2</sub> O <sub>5</sub>	5.16	3.90	4.85	3.89	4.66	5.29	3.83	3.73	4.58	4.26	3.20	2.72
As <sub>2</sub> O <sub>5</sub>												
Reduced composition												
SiO <sub>2</sub> d *	56.11	58.60	56.28	58.86	56.06	56.40	58.97	61.29	58.84	59.94	62.65	61.38
Na <sub>2</sub> O *	0.40	0.60	0.66	0.60	0.59	0.42	0.61	0.63	0.93	0.42	1.33	2.11
CaO *	22.98	18.34	21.13	18.22	21.75	22.19	18.41	15.28	15.75	20.09	17.90	22.55
K <sub>2</sub> O *	13.47	15.81	14.65	15.59	14.21	13.98	15.47	17.50	18.09	12.37	10.51	5.71
MgO *	4.21	3.99	4.58	3.95	4.87	4.27	3.92	3.33	4.58	4.37	6.45	3.97
Al <sub>2</sub> O <sub>3</sub> *	1.74	1.82	1.87	1.96	1.75	1.84	1.86	1.50	1.21	2.06	0.70	3.54
Fe <sub>2</sub> O <sub>3</sub> *	1.10	0.83	0.83	0.82	0.76	0.91	0.76	0.47	0.61	0.75	0.45	0.74
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00



	8112	8113	8114	8115	8116	8117	8118	8119	8120	8121	8122	8123
SiO <sub>2</sub> d	58.79	60.54	61.07	63.95	59.89	60.44	61.02	66.11	66.82	65.16	72.06	52.41
Na <sub>2</sub> O	1.30	1.89	1.54	0.37	0.54	3.20	1.69	14.7	10.9	10.8	7.59	0.62
CaO	22.0	21.3	20.6	21.3	20.3	20.1	20.6	12.8	12.8	11.8	5.60	14.7
K <sub>2</sub> O	6.92	4.80	5.47	5.55	7.45	3.45	6.03	1.84	2.36	2.31	10.3	18.6
MgO	2.98	3.28	2.86	2.44	2.75	3.57	3.18	0.21	0.32	0.35	0.10	4.85
Al <sub>2</sub> O <sub>3</sub>	4.10	4.17	3.95	1.99	4.87	4.31	2.35	2.86	2.40	2.46	0.16	1.64
Fe <sub>2</sub> O <sub>3</sub>	0.58	0.55	1.03	0.74	0.95	1.24	0.95	0.21	1.32	1.93	0.25	1.04
TiO <sub>2</sub>	0.12	0.15	0.22	0.18	0.26	0.30	0.17	0.018	0.062	0.063	0.023	0.18
Sb <sub>2</sub> O <sub>5</sub>												
MnO	0.70	0.67	0.81	0.63	1.00	0.68	0.91	0.005	0.32	1.52	0.01	0.91
CuO	0.02	0.005	0.01	0.01	0.03	0.005	0.005	0.63	0.050	0.02	1.98	0.29
CoO										0.03	0.05	0.10
SnO <sub>2</sub>						0.005	0.001		0.001	0.001		0.05
Ag <sub>2</sub> O	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.10	0.003	0.001	0.003	0.0005
PbO		0.005	0.01	0.007	0.005	0.03	0.01	0.43	2.30	3.35	1.22	0.18
BaO												
SrO												
Li <sub>2</sub> O												
Rb <sub>2</sub> O												
B <sub>2</sub> O <sub>3</sub>	0.02	0.03	0.02	0.02	0.02	0.02	0.02		0.01	0.01	0.01	0.03
V <sub>2</sub> O <sub>5</sub>									0.0025	0.0025	0.0025	0.0025
Cr <sub>2</sub> O <sub>3</sub>								0.005				0.005
NiO	0.005	0.005	0.005	0.005	0.005	0.005	0.005			0.03		0.005
ZnO	0.038	0.040	0.083	0.061	0.037	0.046	0.052	0.017	0.012	0.015	0.0005	0.10
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>			0.01	0.01	0.01				0.001	0.02		
P <sub>2</sub> O <sub>5</sub>	2.42	2.56	2.31	2.73	1.88	2.59	3.00	0.058	0.31	0.12	0.64	4.28
As <sub>2</sub> O <sub>5</sub>												
Reduced composition												
SiO <sub>2</sub> d *	60.82	62.72	63.27	66.38	61.90	62.76	63.68	66.96	68.94	68.73	75.01	55.84
Na <sub>2</sub> O *	1.34	1.96	1.60	0.38	0.56	3.32	1.76	14.89	11.25	11.39	7.90	0.66
CaO *	22.76	22.07	21.34	22.11	20.98	20.87	21.50	12.96	13.21	12.45	5.83	15.66
K <sub>2</sub> O *	7.16	4.97	5.67	5.76	7.70	3.58	6.29	1.86	2.43	2.44	10.72	19.82
MgO *	3.08	3.40	2.96	2.53	2.84	3.71	3.32	0.21	0.33	0.37	0.10	5.17
Al <sub>2</sub> O <sub>3</sub> *	4.24	4.32	4.09	2.07	5.03	4.47	2.45	2.90	2.48	2.59	0.17	1.75
Fe <sub>2</sub> O <sub>3</sub> *	0.60	0.57	1.07	0.77	0.98	1.29	0.99	0.21	1.36	2.04	0.26	1.11
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 9 (cont.)  
Chemical Analyses of Saint-Jean-des-Vignes Glasses

	8124	8125	8126	8127	8128	8129	8130	8131	8132	8133	8134	8135
SiO <sub>2</sub> d	55.12	65.22	67.29	67.40	56.65	55.22	53.60	53.04	55.45	55.69	52.48	55.79
Na <sub>2</sub> O	0.43	7.76	12.4	12.4	1.23	1.19	0.54	0.67	0.64	2.02	0.77	0.56
CaO	19.2	7.55	9.68	9.27	13.1	14.7	19.0	14.0	17.5	16.4	13.9	18.8
K <sub>2</sub> O	12.7	7.53	2.13	1.60	15.4	15.6	13.4	18.6	13.8	11.9	18.7	11.8
MgO	4.11	0.17	0.25	0.12	5.48	4.74	3.90	4.95	4.11	6.72	4.91	4.17
Al <sub>2</sub> O <sub>3</sub>	1.93	0.28	1.02	0.74	2.18	1.64	1.63	1.66	1.49	1.15	1.68	2.11
Fe <sub>2</sub> O <sub>3</sub>	0.80	0.29	0.28	1.39	0.90	0.87	1.04	1.05	1.12	0.88	1.22	0.90
TiO <sub>2</sub>	0.23	0.026	0.033	0.034	0.25	0.18	0.21	0.18	0.21	0.16	0.18	0.23
Sb <sub>2</sub> O <sub>5</sub>				0.30								
MnO	0.59	0.018	0.11	0.72	0.91	1.11	0.65	1.00	0.73	1.00	1.01	0.56
CuO	0.12	1.89	1.33	1.98	0.13	0.19	0.10	0.15	0.080	0.15	0.24	0.14
CoO	0.08	0.10	0.10	0.12	0.08	0.08	0.15	0.10	0.10	0.10	0.15	0.10
SnO <sub>2</sub>	0.01	0.001	0.001	0.01	0.01	0.10	0.02	0.02	0.02	0.02	0.05	0.02
Ag <sub>2</sub> O	0.0005	0.10	0.50	0.001	0.001	0.0005	0.0005	0.0005	0.001	0.02	0.001	0.0005
PbO	0.05	7.29	4.66	3.55	0.15	0.28	0.24	0.12	0.18	0.21	0.21	0.12
BaO												
SrO												
Li <sub>2</sub> O												
Rb <sub>2</sub> O												
B <sub>2</sub> O <sub>3</sub>	0.03	0.01	0.01	0.01	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
V <sub>2</sub> O <sub>5</sub>	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Cr <sub>2</sub> O <sub>3</sub>	0.005			0.005								
NiO		0.005	0.03	0.05								
ZnO	0.12	0.003	0.020	0.023	0.14	0.13	0.28	0.18	0.25	0.27	0.27	0.18
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>			0.02									
P <sub>2</sub> O <sub>5</sub>	4.47	1.75	0.13	0.069	3.35	3.93	5.20	4.24	4.28	3.27	4.19	4.48
As <sub>2</sub> O <sub>5</sub>				0.20								
Reduced composition												
SiO <sub>2</sub> d*	58.46	73.45	72.32	72.54	59.67	58.77	57.57	56.44	58.92	58.77	56.03	59.27
Na <sub>2</sub> O*	0.46	8.74	13.33	13.34	1.30	1.27	0.58	0.71	0.68	2.13	0.82	0.59
CaO*	20.36	8.50	10.40	9.98	13.80	15.64	20.41	14.90	18.59	17.31	14.84	19.97
K <sub>2</sub> O*	13.47	8.48	2.29	1.72	16.22	16.60	14.39	19.79	14.66	12.56	19.97	12.54
MgO*	4.36	0.19	0.27	0.13	5.77	5.04	4.19	5.27	4.37	7.09	5.24	4.43
Al <sub>2</sub> O <sub>3</sub> *	2.05	0.32	1.10	0.80	2.30	1.75	1.75	1.77	1.58	1.21	1.79	2.24
Fe <sub>2</sub> O <sub>3</sub> *	0.85	0.33	0.30	1.50	0.95	0.93	1.12	1.12	1.19	0.93	1.30	0.96
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	8136	8137	8138	8139	8140	8141	8142	8143	8144	8145	8146	8147
SiO <sub>2</sub> d	56.88	60.26	68.59	69.83	70.71	54.99	68.45	66.36	58.10	54.19	54.07	52.59
Na <sub>2</sub> O	0.33	1.37	7.49	1.98	13.2	0.86	14.5	13.7	0.48	0.27	0.23	0.87
CaO	18.7	15	4.94	5.31	11.5	15.6	13.2	8.78	13.4	15.5	14.2	15.7
K <sub>2</sub> O	11.4	10.9	8.56	17.1	0.65	16.1	1.07	1.03	16.7	19.1	22.3	16.2
MgO	3.94	5.94	0.11	0.24	0.05	5.8	0.17	0.096	4.55	3.85	3.35	5.71
Al <sub>2</sub> O <sub>3</sub>	2.00	0.89	0.36	0.33	1.47	0.89	2.01	1.91	1.37	2.45	2.26	2.03
Fe <sub>2</sub> O <sub>3</sub>	0.90	0.88	0.21	0.16	0.14	0.37	0.26	2.46	0.57	0.37	0.37	0.79
TiO <sub>2</sub>	0.24	0.072	0.021	0.017	0.010	0.11	0.052	0.078	0.17	0.10	0.080	0.16
Sb <sub>2</sub> O <sub>5</sub>												
MnO	0.55	0.65	0.01	4.58	2.07	1.83	0.10	2.48	0.74	1.29	1.22	0.92
CuO	0.14	0.14	0.31	0.005	0.005	0.013	0.005	0.016	0.005	0.008	0.005	0.005
CoO	0.15	0.18	0.15									
SnO <sub>2</sub>	0.05	0.02			0.001			0.001			0.001	0.001
Ag <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
PbO	0.05	0.06	8.21	0.20	0.01	0.01	0.05	2.95	0.01	0.02	0.17	0.01
BaO	0.10	0.10	0.01	0.02	0.10	0.05	0.03	0.05	0.05	0.10	0.05	0.05
SrO	0.03	0.03	0.005	0.01	0.01	0.03	0.01	0.02	0.02	0.02	0.02	0.02
Li <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Rb <sub>2</sub> O	0.02	0.01	0.01	0.01	0.01		0.02			0.01	0.01	0.01
B <sub>2</sub> O <sub>3</sub>	0.05	0.05		0.02	0.005	0.05	0.005	0.0005	0.05	0.05	0.05	0.05
V <sub>2</sub> O <sub>5</sub>												
Cr <sub>2</sub> O <sub>3</sub>												
NiO	0.01	0.10	0.02	0.02	0.02	0.01		0.005		0.005		0.005
ZnO	0.17	0.078	0.0005	0.0005	0.005	0.043	0.003	0.0005	0.040	0.030	0.005	0.051
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>												
P <sub>2</sub> O <sub>5</sub>	4.28	3.26	0.99	0.16	0.029	3.24	0.063	0.058	3.74	2.63	1.60	4.82
As <sub>2</sub> O <sub>5</sub>												
Reduced composition												
SiO <sub>2</sub> d *	60.42	63.27	75.99	73.54	72.36	58.12	68.68	70.34	61.05	56.61	55.87	56.01
Na <sub>2</sub> O *	0.35	1.44	8.30	2.09	13.51	0.91	14.55	14.52	0.50	0.28	0.24	0.93
CaO *	19.86	15.75	5.47	5.59	11.77	16.49	13.25	9.31	14.08	16.19	14.67	16.72
K <sub>2</sub> O *	12.11	11.44	9.48	18.01	0.67	17.02	1.07	1.09	17.55	19.95	23.04	17.25
MgO *	4.18	6.24	0.12	0.25	0.05	6.13	0.17	0.10	4.78	4.02	3.46	6.08
Al <sub>2</sub> O <sub>3</sub> *	2.12	0.93	0.40	0.35	1.50	0.94	2.02	2.02	1.44	2.56	2.34	2.16
Fe <sub>2</sub> O <sub>3</sub> *	0.96	0.92	0.23	0.17	0.14	0.39	0.26	2.61	0.60	0.39	0.38	0.84
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 9 (cont.)  
Chemical Analyses of Saint-Jean-des-Vignes Glasses

	8148	8149	8150	8151	8152	8153	8154	8155	8156	8157	8158	8159
SiO <sub>2</sub> d	73.41	55.68	54.43	54.32	53.48	52.93	55.46	50.37	51.44	58.11	59.58	61.06
Na <sub>2</sub> O	15.2	0.47	0.59	0.59	0.48	0.45	0.67	0.53	0.44	0.77	0.60	1.62
CaO	7.65	13.3	14.9	15.1	15.2	13.9	15.3	17.2	19.5	14.2	13.8	20.4
K <sub>2</sub> O	2.73	18.5	16.5	16.4	18.4	19.0	15.1	17.2	16.2	14.6	13.6	5.68
MgO	0.098	4.49	5.95	6.02	4.69	5.69	5.68	5.36	3.7	4.84	4.52	3.26
Al <sub>2</sub> O <sub>3</sub>	0.45	1.46	1.15	1.22	1.53	1.57	1.29	1.33	1.08	1.46	2.16	3.78
Fe <sub>2</sub> O <sub>3</sub>	0.13	0.67	0.46	0.43	0.68	0.70	0.55	0.43	0.49	0.61	0.71	0.67
TiO <sub>2</sub>	0.017	0.17	0.14	0.13	0.17	0.17	0.15	0.14	0.094	0.16	0.26	0.11
Sb <sub>2</sub> O <sub>5</sub>												
MnO	0.10	0.77	0.97	0.96	0.79	0.88	0.94	2.1	0.39	0.91	0.92	0.72
CuO	0.0005	0.24	0.13	0.081	0.12	0.30	0.3	0.029	0.35	0.39	0.055	0.01
CoO												
SnO <sub>2</sub>		0.01	0.001	0.001	0.01	0.03	0.01	0.002	0.027	0.026	0.0005	
Ag <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
PbO	0.05	0.01	0.01	0.005	0.01	0.01	0.01	0.03	0.02	0.10	0.01	0.001
BaO		0.05	0.10	0.05	0.05	0.05	0.05	0.10	0.10	0.05	0.10	0.05
SrO		0.01	0.01	0.01	0.02	0.02	0.02	0.03	0.05	0.02	0.05	0.02
Li <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005		0.0005	0.0005	0.0005	0.0005
Rb <sub>2</sub> O	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01	
B <sub>2</sub> O <sub>3</sub>	0.08	0.005	0.08	0.05	0.05	0.05	0.05	0.03	0.03	0.05	0.03	0.03
V <sub>2</sub> O <sub>5</sub>								0.0025	0.0025	0.0025	0.0025	0.0025
Cr <sub>2</sub> O <sub>3</sub>												
NiO												
ZnO	0.0005	0.056	0.059	0.062	0.073	0.058	0.059	0.055	0.1	0.1	0.049	0.025
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>												
P <sub>2</sub> O <sub>5</sub>	0.067	4.09	4.50	4.56	4.23	4.18	4.35	5.05	5.96	3.58	3.54	2.56
As <sub>2</sub> O <sub>5</sub>												
Reduced composition												
SiO <sub>2</sub> d*	73.65	58.88	57.92	57.74	56.62	56.16	58.97	54.50	55.40	61.43	62.73	63.29
Na <sub>2</sub> O*	15.25	0.50	0.63	0.63	0.51	0.48	0.71	0.57	0.47	0.81	0.63	1.68
CaO*	7.68	14.06	15.85	16.05	16.09	14.75	16.27	18.61	21.00	15.01	14.53	21.15
K <sub>2</sub> O*	2.74	19.56	17.56	17.43	19.48	20.16	16.06	18.61	17.45	15.44	14.32	5.89
MgO*	0.10	4.75	6.33	6.40	4.97	6.04	6.04	5.80	3.98	5.12	4.76	3.38
Al <sub>2</sub> O <sub>3</sub> *	0.45	1.54	1.22	1.30	1.62	1.67	1.37	1.44	1.16	1.54	2.27	3.92
Fe <sub>2</sub> O <sub>3</sub> *	0.13	0.71	0.49	0.46	0.72	0.74	0.58	0.47	0.53	0.64	0.75	0.69
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

	8160	8161	8162	8163	8164	8165	8166	8167	8168
SiO <sub>2</sub> d	52.00	55.22	53.37	71.44	69.01	73.68	72.43	56.39	58.74
Na <sub>2</sub> O	0.57	0.69	0.49	12.9	11.9	13.2	11.8	1.15	0.91
CaO	18.4	15.3	14.6	12.1	13.8	11.7	12.7	14.7	17.7
K <sub>2</sub> O	13.3	15.1	18.9	0.76	1.33	0.17	0.66	14.6	9.46
MgO	7.64	5.7	4.93	0.089	0.51	0.070	0.15	5.47	3.27
Al <sub>2</sub> O <sub>3</sub>	1.89	1.41	1.40	1.52	2.58	0.5	1.73	2.22	3.43
Fe <sub>2</sub> O <sub>3</sub>	0.57	0.57	0.67	0.27	0.23	0.21	0.28	0.64	1.52
TiO <sub>2</sub>	0.079	0.15	0.16	0.015	0.017	0.017	0.016	0.24	0.31
Sb <sub>2</sub> O <sub>5</sub>									
MnO	0.59	0.94	0.76	0.65	0.44	0.005	0.088	0.76	0.53
CuO	0.025	0.25	0.25	0.016	0.001	0.096	0.02	0.32	0.046
CoO									0.08
SnO <sub>2</sub>	0.0005	0.003	0.020	0.10	0.002	0.20	0.042	0.033	0.007
Ag <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
PbO	0.05	0.02	0.02	0.02	0.01	0.01	0.01	0.05	0.05
BaO	0.10	0.10	0.10	0.05	0.10		0.03	0.05	0.10
SrO	0.02	0.02	0.02	0.01	0.01			0.01	0.05
Li <sub>2</sub> O	0.0005			0.0005	0.0005		0.0005	0.0005	
Rb <sub>2</sub> O	0.01	0.01	0.01					0.01	0.01
B <sub>2</sub> O <sub>3</sub>	0.04	0.03	0.03					0.03	0.03
V <sub>2</sub> O <sub>5</sub>	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Cr <sub>2</sub> O <sub>3</sub>	0.005					0.005		0.005	
NiO									
ZnO	0.053	0.06	0.060	0.003	0.008	0.005	0.002	0.070	0.095
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>									
P <sub>2</sub> O <sub>5</sub>	4.65	4.42	4.20	0.050	0.044	0.027	0.031	3.24	3.65
As <sub>2</sub> O <sub>5</sub>						0.10			
Reduced composition									
SiO <sub>2</sub> d*	55.10	58.75	56.56	72.10	69.45	74.03	72.61	59.25	61.81
Na <sub>2</sub> O*	0.60	0.73	0.52	13.02	11.98	13.26	11.83	1.21	0.96
CaO*	19.50	16.28	15.47	12.21	13.89	11.76	12.73	15.45	18.62
K <sub>2</sub> O*	14.09	16.07	20.03	0.77	1.34	0.17	0.66	15.34	9.95
MgO*	8.10	6.06	5.22	0.09	0.51	0.07	0.15	5.75	3.44
Al <sub>2</sub> O <sub>3</sub> *	2.00	1.50	1.48	1.53	2.60	0.50	1.73	2.33	3.61
Fe <sub>2</sub> O <sub>3</sub> *	0.60	0.61	0.71	0.27	0.23	0.21	0.28	0.67	1.60
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

TABLE 9 (cont.)  
Chemical Analyses of Saint-Jean-des-Vignes Glasses

	8169	8170	8171	8172	8174	8175	8176
SiO <sub>2</sub> d	61.67	61.69	59.07	61.37	64.81	65.77	59.87
Na <sub>2</sub> O	1.88	1.83	0.69	1.81	5.01	5.67	0.73
CaO	20.4	20.5	21.0	20.0	16.2	16.3	16.2
K <sub>2</sub> O	4.64	4.63	6.77	4.88	3.54	4.81	14.2
MgO	3.13	3.19	3.89	3.08	3.66	2.43	3.38
Al <sub>2</sub> O <sub>3</sub>	4.23	4.11	4.33	4.72	2.98	2.08	1.41
Fe <sub>2</sub> O <sub>3</sub>	0.56	0.54	0.83	0.62	0.93	0.84	0.47
TiO <sub>2</sub>	0.15	0.14	0.21	0.16	0.24	0.12	0.16
Sb <sub>2</sub> O <sub>5</sub>							
MnO	0.62	0.62	0.74	0.63	0.43	0.34	1.24
CuO	0.01	0.005	0.01	0.005	0.001	0.005	0.005
CoO			0.01				
SnO <sub>2</sub>			0.001		0.006	0.006	
Ag <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
PbO	0.01	0.001	0.005	0.003	0.03	0.16	
BaO	0.05	0.10	0.10	0.10	0.05	0.10	0.10
SrO	0.02	0.02	0.01	0.05	0.10	0.05	0.03
Li <sub>2</sub> O	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Rb <sub>2</sub> O						0.01	0.03
B <sub>2</sub> O <sub>3</sub>	0.04	0.03	0.04	0.03	0.04	0.02	0.03
V <sub>2</sub> O <sub>5</sub>	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Cr <sub>2</sub> O <sub>3</sub>							
NiO			0.005				0.005
ZnO	0.042	0.04	0.032	0.038	0.037	0.018	0.027
ZrO <sub>2</sub>	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Bi <sub>2</sub> O <sub>3</sub>							
Bi <sub>2</sub> O <sub>5</sub>	0.005	0.005	0.01	0.005			
P <sub>2</sub> O <sub>5</sub>	2.53	2.54	2.24	2.49	1.93	1.06	2.10
As <sub>2</sub> O <sub>5</sub>						0.20	
Reduced composition							
SiO <sub>2</sub> d *	63.90	63.93	61.16	63.61	66.72	67.18	62.20
Na <sub>2</sub> O *	1.95	1.90	0.71	1.88	5.16	5.79	0.76
CaO *	21.14	21.25	21.74	20.73	16.68	16.65	16.83
K <sub>2</sub> O *	4.81	4.80	7.01	5.06	3.64	4.91	14.75
MgO *	3.24	3.31	4.03	3.19	3.77	2.48	3.51
Al <sub>2</sub> O <sub>3</sub> *	4.38	4.26	4.48	4.89	3.07	2.12	1.46
Fe <sub>2</sub> O <sub>3</sub> *	0.58	0.56	0.86	0.64	0.96	0.86	0.49
T	100.00	100.00	100.00	100.00	100.00	100.00	100.00

No. 8173 was not analyzed.