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THE CITY of Ramla was founded as the provincial capital in the days of the Umayyad caliph al-Walīd ibn ʻAbd al-Malik (705–715).[1] In recent salvage excavations at the southern end of the modern city, an industrial quarter that probably produced flax between the eighth and 10th centuries was unearthed.[2] Remains of earlier periods were also discovered, including an occupation layer of the sixth and seventh centuries.[3] That layer revealed several features:

1. An ashlar-built domestic structure consisting of several rooms, one of which featured a rough white mosaic floor. Another room had a round, deep plastered pool that served an industry that has not yet been identified.
2. An oil press equipped with two parallel beam presses operated by a screw.
3. A plastered, stepped pool that was part of another industrial installation. It later became a refuse pit dated by finds to the sixth and seventh centuries.
4. Two wine presses with rough white mosaic treading floors and settling pits at the corners.
5. Remains of pottery kilns.
6. Debris from a secondary glass workshop.

The glassworking debris (Locus 966), which was related to the production of vessels, was found in one of the excavated squares (Y134) on virgin red loam (*ḥamra*) following the dismantling of walls from an installation that was attributed to the early Islamic period. Although we were unable to connect the architectural remains and the workshop debris with certainty, we recovered several fragmentary glazed and unglazed fired mud bricks, sometimes mixed with fieldstones, that probably formed part of the workshop's furnace. The bricks (Th. 2 cm) can be reconstructed as about 12 centimeters square (Fig. 1). Fired mud bricks were often used to build pottery kilns and glass furnaces. Evidence for the use of such bricks, occasionally mixed with fieldstones, has been found in furnaces at late Roman Jalame and medieval Givʻat Yasaf

1. For the Arabic historical sources on the founding of Ramla, see Guy Le Strange, *Palestine under the Moslems: A Description of Syria and the Holy Land from A.D. 650 to 1500*, Beirut: Khayats, 1965 (reprint of 1890 ed.), pp. 303–308. For an archeological account of Palestine in the early Islamic period, see Robert Schick, "Archaeological Sources for the History of Palestine. Palestine in the Early Islamic Period: Luxuriant Legacy," *Near Eastern Archaeology*, v. 61, no. 2, 1998, pp. 74–107. For a summary of the excavations carried out in Ramla and visible ancient remains, see Andrew Petersen, *The Towns of Palestine under Muslim Rule, AD 600–1600*, BAR International Series 1381, Oxford: Archaeopress, 2005, pp. 95–102; see also the Hebrew periodical *Qadmoniot*, v. 135 (in press), which is dedicated in full to the archeology of Ramla. For an updated historical overview of Palestine in the early Islamic period, see Moshe Gil, *A History of Palestine, 634–1099*, Cambridge: Cambridge University Press, 1992.

2. Oren Tal and Itamar Taxel, "A Flax Processing Site of the Early Islamic Period?" *Qadmoniot*, v. 135, in press (in Hebrew); *idem*, *Ramla (South): An Early Islamic Industrial Site and Remains of Previous Periods*, Salvage Excavation Reports 5, Tel Aviv: Tel Aviv University, in press.

3. From a historical Palestinian perspective, the sixth and seventh centuries refer to the late Byzantine (up to 638), Sasanian (614–628), and early Islamic (from 638) periods. From a material culture Palestinian perspective, these two centuries (which are described in this article as "late Byzantine") demonstrate continuity rather than innovation (but with evidence of the abandonment of some military installations, churches, and monasteries); see Jodi Magness, *The Archaeology of the Early Islamic Settlement in Palestine*, Winona Lake: Eisenbrauns, 2003.

FIG. 1. *Glazed and unglazed fired mud bricks from workshop furnace. (Photo: Pavel Shrago)*

FIG. 2. *Debris from glass workshop. (Photo: Pavel Shrago)*

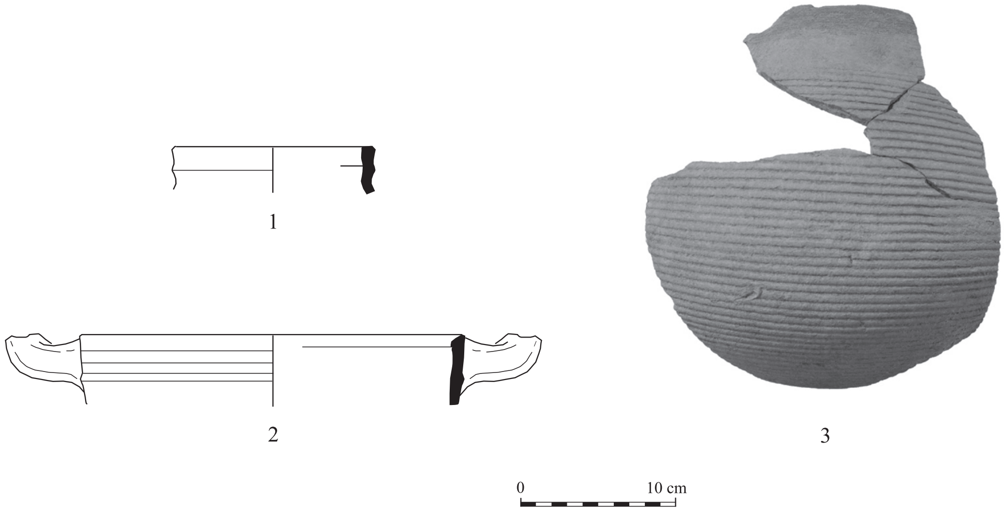

FIG. 3. *Pottery from glass workshop. (Drawings: Natalie Messika; photo: Pavel Shrago)*

(Tell er-Ras/Somelaria) in Israel, and in many glass furnaces in western Europe.[4]

The glass refuse consists of raw chunks and lumps, moils, waste (including drops, threads, and melted and deformed vessels), and fragmentary vessels (Fig. 2). The dating to the sixth and seventh centuries is based on the discovery of pottery sherds (Fig. 3) as well as the glass vessels (Fig. 4). Among the many pottery finds were rim fragments of a Palestinian bag-shaped jar (Fig. 3.1), which, based on several local discoveries of the remains of pottery kilns that produced jars of this type, was locally made (Fig. 5);[5] and a deep ribbed-wall casserole (Fig. 3.2).[6] The debris was sealed by fills that yielded pottery of similar (late Byzantine) date, including body fragments of the Palestinian bag-shaped jar type (e.g., Fig. 3.3).[7]

The glass finds can be described as follows:

4. For Jalame, see Gladys D. Weinberg, "The Glass Factory and Manufacturing Processes," in *Excavations at Jalame, Site of a Glass Factory in Late Roman Palestine*, ed. Gladys Davidson Weinberg, Columbia: University of Missouri Press, 1988, pp. 28–33, figs. 3–8, pls. 3 and 4B, color pl. 2D. For Giv'at Yasaf (Tell er-Ras/Somelaria), see *idem*, "A Glass Factory of Crusader Times in Northern Israel (Preliminary Report)," *Annales de l'Association Internationale pour l'Histoire du Verre*, v. 10, Madrid/Segovia, 1985 (Amsterdam, 1987), pp. 305–316. Comparison with the evidence from western Europe reveals that secondary glass furnaces vary in shape (rounded or rectangular) and are constructed of bricks, tiles, and stones. In most cases, only the lower part of the furnace is preserved, and the reconstruction of glass furnaces is therefore usually based on iconographic sources, which are few and difficult to interpret. See Danièle Foy and Marie-Dominique Nenna, *Tout feu tout sable: Mille ans de verre antique dans le Midi de la France*, Marseilles: Musées de Marseille and Aix-en-Provence: Edisud, 2001, pp. 47–66. In fact, the iconographic (archeological) sources are restricted almost to a lamp and a terra-cotta, both of which are dated to the early Roman period and show two levels in a rounded glass furnace. The lower level probably included the firing chamber, divided into two parts, and the upper level probably consisted of melting chambers, also divided into two sections, where the raw glass and recycled cullet were melted. See Jennifer Price, "Exhibits at Ballots: An Egyptian Terracotta Group Showing Eros beside a Glass Furnace," *The Antiquaries Journal*, v. 68, pt. 2, 1988, pp. 317–319; and E. Marianne Stern, *The Toledo Museum of Art. Roman Mold-Blown Glass: The First through Sixth Centuries*, Rome: "L'Erma" di Bretschneider in association with the museum, 1995, p. 22; and Foy and Nenna, *Tout feu*, pp. 61–62.

5. For this type of jar and its dating, see, for example, Sean A. Kingsley, "Bag-Shaped Amphorae and Byzantine Trade: Expanding Horizons," *Bulletin of the Anglo-Israel Archaeological Society*, v. 14, 1994–1995, pp. 39–56, esp. fig. 3, group 2.

6. For this type of casserole and its dating, see, for example, Jodi Magness, *Jerusalem Ceramic Chronology, circa 200–800 C.E.*, JSOT/ASOR Monograph Series, no. 9, Sheffield: Sheffield Academic Press, 1993, pp. 211–213, form 1, esp. no. 12.

7. See note 5.

FIG. 4. *Glass vessels from workshop debris. (Photo: Pavel Shrago)*

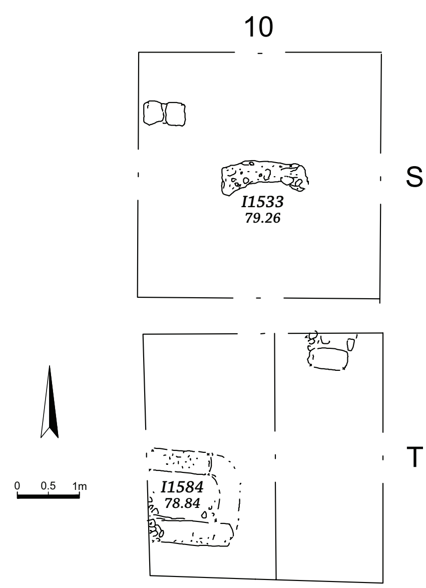

FIG. 5. *Remains of pottery kiln. (Survey and drawing: Dov Porotsky; photo: Pavel Shrago)*

Primary Product Remains

Six raw chunks (largest: about 3 x 1.5 cm) of yellowish green and bluish green glass, covered with a layer of silver weathering, probably broken from larger chunks and used to produce vessels (Fig. 6). Alternatively, these chunks may be the remains of primary glass chunks, small lumps, and recycled vessel fragments (i.e., cullet) melted in the furnace. However, the fact that, with a single exception (Table 1, no. 4, that is well outside, but only in potash) all of the analyzed glasses display precisely the same correlation between the various chemical components strongly suggests that all of them came from the same furnace and represent a single source for

FIG. 6. *Raw glass chunks. (Photo: Pavel Shrago)*

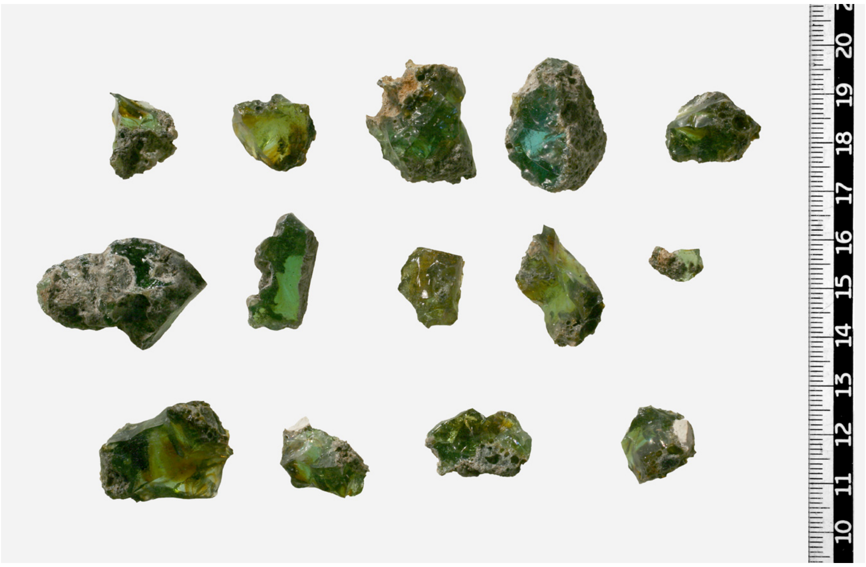

FIG. 7. *Glass lumps. (Photo: Pavel Shrago)*

the glass. It also argues against the use of cullet. In debris from furnaces that appear to have been used exclusively for the remelting of cullet (e.g., San Vincenzo, Italy, in which old vessels were melted in pots), there is no evidence of such chunks.[8]

About 30 small (1–4 cm), rounded, and uneven lumps of blue and green glass covered with a thick layer of limy/ashy material. These lumps may be waste from the mixing of raw glass in the furnace. They may have been left on the floor and sides of the furnace, thus becoming contaminated with lime, or they may have been remelted with cullet (Fig. 7). The material covering these

8. Personal observation of Ian C. Freestone, who surveyed and sampled glass from the San Vincenzo workshops in 1996.

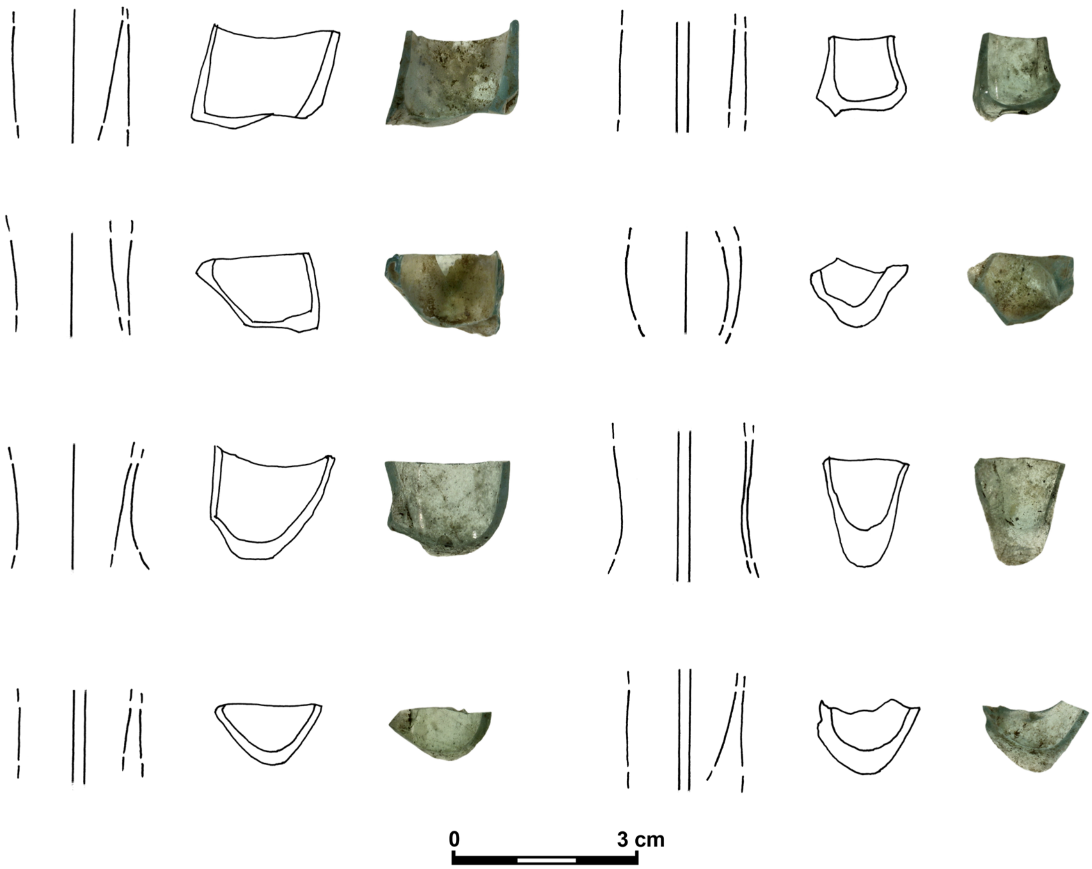

FIG. 8. *Moils. (Drawings: Ada Perry; photos: Pavel Shrago)*

lumps may be ash or a fuel-ash slag. As is noted below, the primary glass used at Ramla (South) was contaminated by unusual quantities of fuel ash. These lumps may be direct evidence of that process.

Vessel Production Remains

Thirteen moils made of colorless glass with a bluish tinge and covered with silver weathering. Moils are waste glass that remains around the end of the blowing tube after the vessel has been removed.[9] They are typically cylindrical rods with one end cut off straight and the other end left rounded and uneven. The moils (D. 1–2 cm) clearly indicate the use of blowing tubes for the production of glass at the site (Fig. 8). Glass moils appear in two basic shapes, depending on their distance from the blowing tube. Narrow cylindrical moils, like the finds at Ramla (South), indicate the upper part of the glass left around the end of the blowing tube, while broader moils, shaped like the upper part of a bowl (like the ones found, together with cylindrical types, in a

9. See, for example, Jennifer Price, "The Social Context of Glass Production in Roman Britain," in *The Prehistory and History of Glassmaking Technology*, ed. Patrick McCray and William D. Kingery, Ceramics and Civilization, no. 8, Westerville, Ohio: American Ceramic Society, 1998, p. 333, n. 4; and Heidi Amrein, *L'Atelier de verriers d'Avenches: L'Artisanat du verre au milieu du 1er siècle après J.-C.*, Aventicum, no. 11, Lausanne: Cahiers d'Archéologie Romande, 2001, p. 22.

FIG. 9. *Working debris. (Photo: Pavel Shrago)*

late Roman glass furnace at Jalame), indicate the lower part of the glass, cut from the top of an open, wide-rimmed vessel.[10]

About 15 fragments of working debris: deformed glass, melted pieces, drops, and threads made of colorless, bluish, and greenish glass, and covered with a thick layer of black and silver weathering. These objects are typical by-products of the making of glass vessels. The drops would have fallen either from the gob of glass removed from the furnace or from the blowing tube while the vessels were being formed. Their shape would be the result of the sudden contact of the warm glass and a cold surface (Fig. 9).[11] Similar finds were discovered at late Roman Jalame.[12]

Final Products

The glass vessels found in the workshop refuse consist of about 50 fragments of colorless glass with a bluish tinge, covered with silver weathering. Most of these fragments cannot be assigned to a specific type, but they include a rim and wall fragment of a wineglass or lamp-bowl with applied horizontal blue trails (Fig. 10.1), a wick-tube from a suspended lamp-bowl (Fig. 10.2), and the base of a stemmed hollow lamp-bowl (Fig. 10.3). There are also straight or infolded

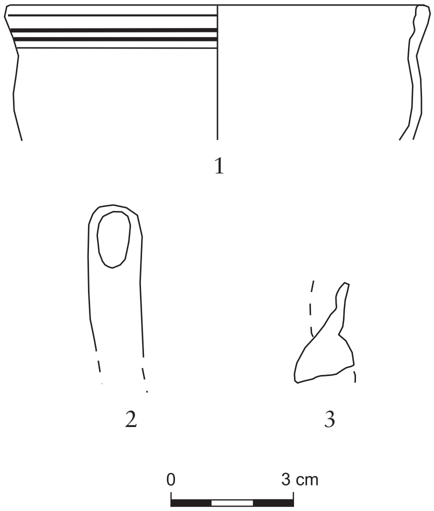

FIG. 10. *Glass vessels from workshop debris. (Drawings: Natalie Messika)*

10. For conical moils, see Weinberg, "The Glass Factory" [note 4], p. 35, pls. 3–5E, color pl. 3A. A considerable quantity of conical moils is known from Avenches; see Amrein [note 9], pp. 22–33, figs. 12.1, 15, 18, and 20–23, pls. 10.5–8, 11.9–16, 12.17–19, and 17.56 and 57, with many western European parallels. For broad moils, see Gladys D. Weinberg and Sidney M. Goldstein, "The Glass Vessels," in *Excavations at Jalame* [note 4], pp. 87–89 and 98–101, figs. 4.45 and 52. See also Amrein [note 9], p. 23, fig. 12.2.

11. Amrein [note 9], pp. 35–37, fig. 31, pl. 13.24–27.

12. Weinberg, "The Glass Factory" [note 4], pp. 33–37, pls. 3–6, color pl. 3A.

TABLE 1

Analysis of Glass from Ramla by Electron Microprobe*

	1 *Chunk*	2 *Chunk*	3 *Chunk*	4 *Chunk*	5 *Chunk*	6 *Chunk*	7 *Vessel*	8 *Vessel*
SiO_2	71.00	70.04	70.91	69.53	70.57	69.88	70.36	70.57
TiO_2	0.11	0.12	0.11	0.10	0.11	0.13	0.11	0.12
Al_2O_3	3.03	2.90	2.88	3.06	2.84	2.91	2.95	2.92
Fe_2O_3	0.66	0.62	0.55	0.55	0.57	0.65	0.60	0.61
MnO	0.03	0.02	0.03	0.01	0.02	0.03	0.03	0.03
MgO	0.70	0.71	0.61	0.64	0.68	0.75	0.69	0.69
CaO	8.62	9.36	8.36	8.71	8.65	9.27	8.86	8.70
Na_2O	14.03	13.88	14.76	13.77	14.40	13.95	14.41	14.40
K_2O	0.94	1.41	0.88	2.67	1.19	1.48	1.06	1.03
P_2O_5	0.13	0.23	0.12	0.20	0.18	0.28	0.17	0.16
SO_3	0.07	0.04	0.05	0.05	0.06	0.05	0.07	0.08
Cl	0.69	0.68	0.73	0.71	0.72	0.61	0.70	0.69
Total	100.51	100.35	100.14	100.45	100.45	100.45	100.30	100.33

*The data are in weight percent, normalized to 100%. Original analytical totals, after correction to secondary standards, are given.

bottle rims, concave bottle bases, a wineglass base, and a mold-blown wall fragment. These fragments were probably the remains of glass products made in the furnace. However, they could have been used as cullet. In either case, the homogeneity of their chemical composition indicates that they represent types of vessels produced in the furnace.

CHEMICAL ANALYSES OF THE GLASS WORKSHOP DEBRIS

Samples of the glass were analyzed with a JEOL JXA-8600 Superprobe at the Institute of Archaeology, University College London,[13] using the same technique, instrument, and operator that we have employed in our earlier studies.[14] The results are presented in Table 1.[15]

13. The analyses, conducted courtesy of Thilo Rehren, were performed by Kevin Reeves.

14. Oren Tal, Ruth E. Jackson-Tal, and Ian C. Freestone, "New Evidence of the Production of Raw Glass at Late Byzantine Apollonia-Arsuf, Israel," *Journal of Glass Studies*, v. 46, 2004, pp. 51–66; Ian C. Freestone, Ruth E. Jackson-Tal, and Oren Tal, "Raw Glass and the Production of Glass Vessels at Late Byzantine Apollonia-Arsuf, Israel," pp. 67–80 in this volume.

15. Each analysis represents the mean of at least six spots on the glass fragment. Average relative standard errors were 0.2% for SiO_2, 0.5% for Na_2O, 0.5% for CaO, 0.8% for Al_2O_3, 2% for K_2O, 2% for MgO, 3% for Fe_2O_3, 2% for Cl, 13% for SO_3, and 8% for P_2O_5. The results were checked against Corning Museum ancient glass standards A and B, as well as a commercially available glass standard. Small corrections were made to the CaO, Al_2O_3, and Fe_2O_3 values to bring them in line with the standards.

9 *Vessel*	10 *Vessel*	11 *Vessel*	12 *Vessel*	13 *Vessel*	14 *Moil*	15 *Moil*	16 *Moil(?)*
70.55	70.45	70.27	70.67	70.27	70.68	70.46	70.94
0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.11
3.07	2.91	2.95	2.95	2.98	2.90	2.92	2.90
0.63	0.62	0.61	0.58	0.59	0.61	0.61	0.60
0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.01
0.74	0.70	0.70	0.68	0.71	0.70	0.70	0.67
8.46	8.80	8.78	9.14	9.65	8.47	8.69	8.43
14.51	14.29	14.25	13.78	13.45	14.62	14.53	14.48
0.96	1.11	1.36	1.11	1.30	0.97	0.99	0.92
0.14	0.19	0.19	0.17	0.20	0.15	0.16	0.13
0.09	0.07	0.07	0.06	0.05	0.08	0.08	0.08
0.70	0.70	0.69	0.71	0.66	0.72	0.73	0.74
100.44	100.45	100.41	100.48	100.51	100.41	100.55	99.14

These are soda-lime-silica glasses with low potash (K_2O) and/or magnesia (MgO). This means that they are also natron glasses, as is typical for the first millennium C.E. until the ninth century (Table 1). The glasses are similar in composition, but they show some variation, notably in K_2O, which ranges from 0.88 to 2.67 wt %; most of the other oxides vary significantly, but over a limited range. The vessels and raw glasses show more or less similar compositional ranges.

The variations in composition are best understood through a series of variation diagrams. In particular, lime (CaO) and phosphate (P_2O_5) are strongly correlated (Fig. 11), as are potash and phosphate (Fig. 12). There is a weak correlation between magnesia and these components. On the other hand, soda (Na_2O) and silica (SiO_2) show a positive correlation, and they are negatively correlated with potash, lime, and phosphate (e.g., Fig. 13). The typical components of wood or plant ash—potash, lime, phosphate, and magnesia—increase together in these glasses, and they slightly depress the "glassy" components, silica and soda.

It appears, therefore, that the main source of variation in the glasses is the addition of a vegetal ash. This is unlikely to have been the type of plant ash used to make conventional soda-lime-silica plant-ash glass because such ashes were rich in soda, whereas the soda contents of the present glasses decrease as the other ash components increase. The ash here was rich in potash, lime, magnesia, and phosphate, but low in soda. This is likely to represent contamination

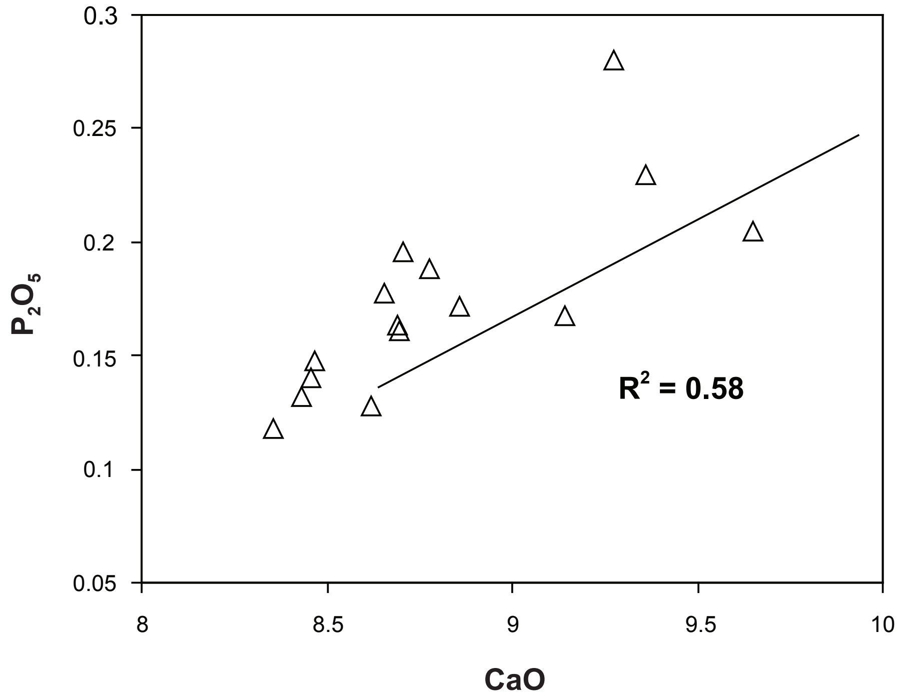

FIG. 11. *Phosphate versus lime in chunk, vessel, and waste glass from Ramla (South), by weight percent.*

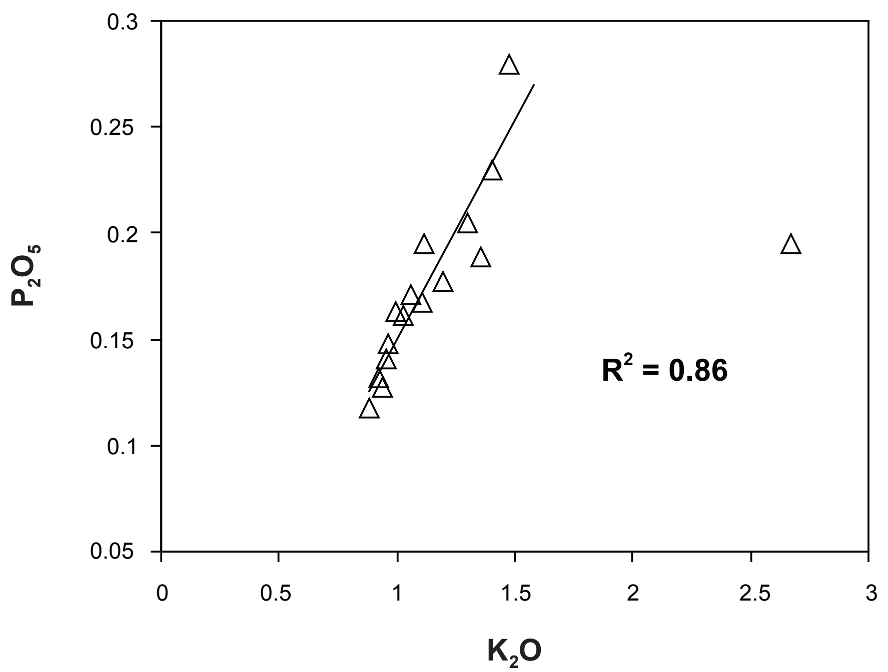

FIG. 12. *Phosphate versus potash in glass from Ramla (South). The calculation of the correlation coefficient (R) did not include the outlier at the right of the diagram.*

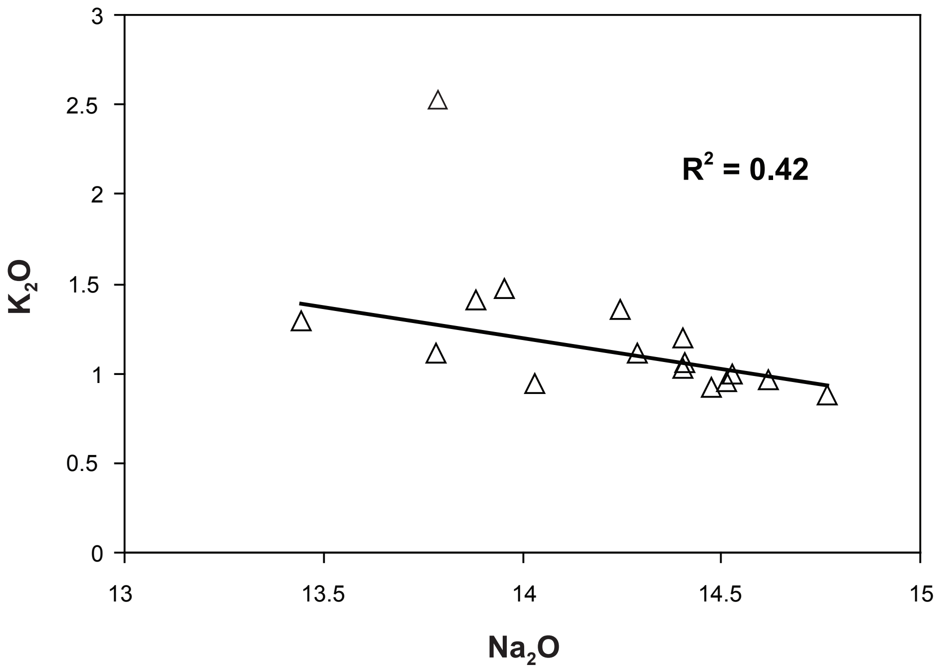

FIG. 13. *Potash versus soda in glass from Ramla (South). Note the negative correlation, which indicates that the ash (high potash) that contaminated the glass was low in soda. The calculation of the correlation coefficient (R) did not include the outlier at the top of the diagram.*

by wood ash, probably from the fuel used to feed the glass furnace. It probably occurred because of a poor separation of glass and fuel in the furnace. This can be seen in the excavated glass lumps surrounded by limy/ashy material.

Levantine glass typically has K_2O values below 1 wt %; higher values are found in a small number of samples, but until now they have been regarded as unusual.[16] The present observations demonstrate that, in this case, such high potash values are based on contamination by fuel ash. The fact that all of the Ramla (South) glass is contaminated, combined with the close correlations between the various components in all but one of the glasses (Fig. 13), strongly supports the view that this assemblage was produced in a single workshop. Furthermore, it is significant that the chunk glass samples show evidence of the same contamination as the vessels and the working debris. Assuming that the chunks represent primary glass rather than remelted material, the contamination occurred at the primary stage of manufacture. Because of some accident or peculiarity in the primary glassmaking process, the glass shows a level of contamination with fuel ash more pervasive than has been observed in other assemblages of Byzantine and early Islamic natron glass from the Levant. Whether this was a one-time accident (in which case, all of the glass analyzed would have come from a single primary melt) or the result of a general practice at one workshop cannot be determined.

16. Ian C. Freestone, Yael Gorin-Rosen, and Michael J. Hughes, "Primary Glass from Israel and the Production of Glass in Late Antiquity and the Early Islamic Period," in *La Route du verre: Ateliers primaires et secondaires du second millénaire av. J.-C. au Moyen Age*, ed. Marie-Dominique Nenna, Travaux de la Maison de l'Orient Méditerranéen, no. 33, Lyons: Maison de l'Orient Méditerranéen–Jean Pouilloux, 2000, pp. 65–83, esp. pp. 77–78, table 2, analyses 13 (a chunk from Apollonia-Arsuf) and 93–100 (chunk glass from Dor, which is also quite high in K_2O). See also N. Schibille, F. Marii, and Th. Rehren, "Characterization and Provenance of Late Antique Window Glass from the Petra Church in Jordan," *Archaeometry*, v. 50, in press.

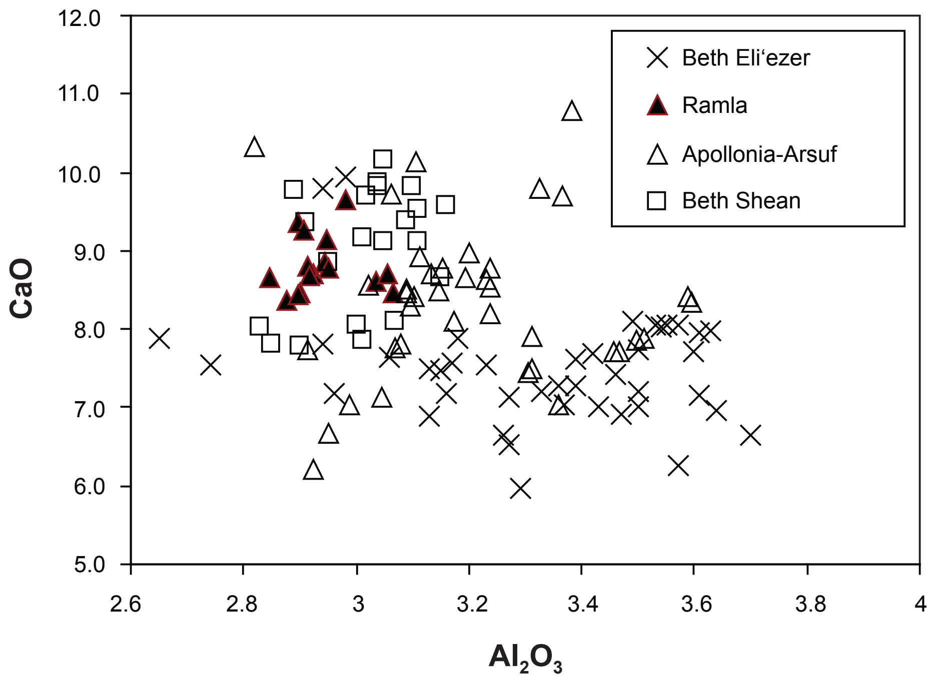

FIG. 14. *Lime versus alumina for raw glass from Beth Eli'ezer, raw glass and vessels from Apollonia-Arsuf, raw glass and vessels from Beth Shean, and raw glass, vessels, and waste from late Byzantine Ramla (South). The Ramla samples tend to group in the upper left of the diagram with the analyzed glass from Apollonia-Arsuf and Beth Shean.*

However, the very close compositional relationship among all of the glasses appears to suggest that they were fired in a single tank, in which case we may suppose that the life of the workshop was relatively short.

What of the exceptional sample with much higher K_2O, which lies removed from the correlation line in Figure 13? This sample was probably contaminated by potash vapor derived from the fuel. It has been shown that, at temperatures above 800°–900°C, large amounts of potassium are released by wood fuel as vapor.[17] It is likely that, in certain critical temperature ranges, potassium vaporized from wood ash in a hotter part of the furnace accumulates in glass in a cooler area. Therefore, this sample is not necessarily from a different batch than the others.

CHRONOLOGICAL COMPARISON WITH OTHER GLASS ASSEMBLAGES IN PALESTINE

The base composition of the Ramla (South) glass, aside from the ashy component, is typical of Byzantine-Islamic natron-type glass from the Levant, with alumina at about 3 wt % (Table 1). Figure 14 compares the Ramla glasses with those from selected sites: the early Islamic tank furnaces at Beth Eli'ezer,[18] the late Byzantine

17. Mahendra K. Misra, Kenneth W. Ragland, and Andrew J. Baker, "Wood Ash Composition as a Function of Furnace Temperature," *Biomass and Bioenergy*, v. 4, no. 2, 1993, pp. 103–116.

18. Freestone, Gorin-Rosen, and Hughes [note 16], table 2, with additional unpublished data of Freestone and Gorin-Rosen.

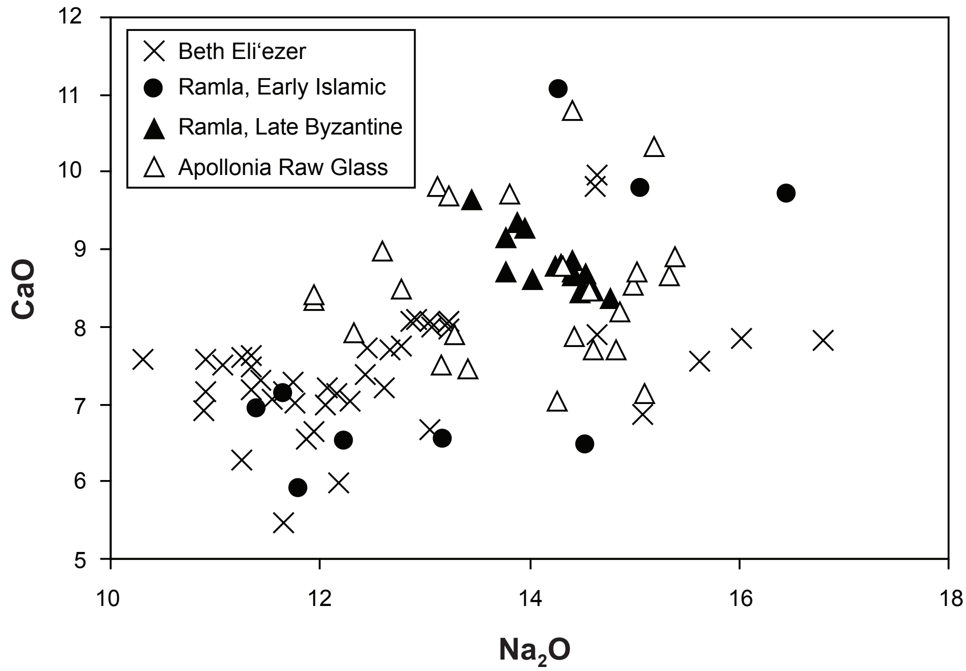

FIG. 15. *Lime versus soda for raw glass from late Byzantine Apollonia-Arsuf, raw glass from early Islamic Beth Eli'ezer, natron glass vessels from early Islamic Ramla, and the late Byzantine Ramla (South) workshop debris.*

secondary workshop at Beth Shean,[19] and Apollonia-Arsuf.[20] The glass from Beth Eli'ezer has elsewhere been termed Levantine II, while Apollonia-Arsuf and Beth Shean glasses fall into the Levantine I grouping.[21] Although there is some overlap, the Ramla glass plots in the upper left of the diagram, with the majority of data from Apollonia-Arsuf and Beth Shean, rather than in the bottom right, with the data from Beth Eli'ezer.

Figure 15 compares Ramla, Apollonia-Arsuf, and Beth Eli'ezer data for soda and lime, adding a group of nine vessels from early Islamic contexts at Ramla.[22] Most of the early Islamic vessels and the Beth Eli'ezer data plot in the lower left, while the present Ramla (South) and Apollonia-Arsuf data have higher CaO and Na_2O. This supports the view that the Ramla workshop glass discussed in this article dates from the late Byzantine period. This result is not unambiguous, however, because some early Islamic vessels are compositionally closer to the Apollonia-Arsuf glasses. Furthermore, we have noted elsewhere[23] that there is considerable overlap between the Apollonia-Arsuf glass and glass from Raqqa, analyzed by Henderson and others, that is attributed to the early Islamic period.

CONCLUSIONS

The evidence discovered in the Ramla (South) workshop debris includes all of the components

19. Ian C. Freestone and Yael Gorin-Rosen, unpublished. For the archeological evidence, see Gabi Mazor and Rachel Bar-Nathan, "The Beth She'an Excavation Project, 1992–1994," *Excavations and Surveys in Israel*, v. 17, 1998, pp. 27–29; and Yael Gorin-Rosen, "The Ancient Glass Industry in Israel: Summary of the Finds and New Discoveries," in *La Route du verre* [note 16], pp. 59–60.

20. Freestone, Jackson-Tal, and Tal [note 14], table 1; Tal, Jackson-Tal, and Freestone [note 14], table 1; Freestone, Gorin-Rosen, and Hughes [note 16], table 2.

21. Freestone, Jackson-Tal, and Tal [note 14]; Freestone, Gorin-Rosen, and Hughes [note 16], pp. 72–74, table 2.

22. Retrieved from excavations carried out by the Israel Antiquities Authority.

23. Freestone, Jackson-Tal, and Tal [note 14].

of secondary glass vessel production: glazed and unglazed bricks from the furnace structure, primary product remains (raw glass chunks and lumps), vessel production remains (working debris), and final products (glass vessels). The chunks and lumps were remelted in the furnace, and the by-products of vessel production are the drops, threads, melted and deformed fragments, and the remains of moils, which indicate the use of a blowing tube. The products of this workshop included everyday tableware, bowls, bottles, lamps, and wineglasses. Most of these were blown, but one fragment was mold-blown.

Secondary glass production is documented in Israel by finds dating from the early Roman to medieval periods.[24] An important find is the furnace remains from Jalame in northern Israel, dated to the second half of the fourth century. They include poor remains of a rectangular furnace with hundreds of glass fragments representing the production process and final products.[25] Clear remains of Byzantine secondary glass production in Israel were found at Kafr Yasif, Ḥorbat Qav, and Sepphoris (in Galilee), Raqit (in the Carmel), Khirbat el-Ni‘ana (in the Shephela), and possibly at a few other sites (including Apollonia-Arsuf).[26] The best-preserved workshop, dated to the late Byzantine period, was found at Beth Shean, but only preliminary findings have been published. The published information from this site presents evidence that is somewhat similar (although much better preserved) to the finds from Ramla (South). It includes remains of the furnace, as well as ash heaps with the remains of olive pits that may have been used for annealing (as is evident from slightly deformed complete glass vessels discovered on top of them). There, too, raw glass, moils, pontil glass chunks, glass drops, and distorted annealed glass vessels were found.[27] An almost complete secondary glass furnace made of fired mud bricks was found at Giv‘at Yasaf (Tell er-Ras/Somelaria) in northern Israel, dated to the 13th century. It included the remains of two firing chambers, a rectangular melting chamber, vents, and working areas, as well as such production debris as raw glass chunks, glass drops, deformed glass vessels, and pots with melted glass.[28]

Secondary glass production is well attested in western Europe (e.g., at Lyons and Avenches).[29] The evidence from Lyons included an artisanal quarter where glass was made alongside such other fire-based industries as the production of pottery. In this respect, it is similar to our evidence from Ramla (South). The documented evidence from western Europe also reveals that the shape of secondary glass furnaces varies; it is usually rounded and sometimes rectangular, made of bricks and tiles.[30]

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24. Gorin-Rosen [note 19], pp. 56–62.

25. Weinberg, "The Glass Factory" [note 4], pp. 24–37.

26. Gorin-Rosen [note 19], pp. 56–62. For Sepphoris, see also Alysia Fischer and W. Patrick McCray, "Glass Production Activities as Practised at Sepphoris, Israel (37 BC–AD 1516)," *Journal of Archaeological Science*, v. 26, 1999, pp. 893–905. For Raqit, see Gusta L. Jacobson, "The Glass Vessels from Horvat Raqit," in *Raqit: Marinus' Estate on the Carmel*, Israel, S. Dar, BAR International Series 1300, Oxford: Archaeopress, 2004, pp. 249–251. For Khirbat el-Ni‘ana, see Yael Gorin-Rosen and Natalya Katsnelson, "Local Glass Production in the Late Roman–Early Byzantine Periods in Light of the Glass Finds from Khirbat el-Ni‘ana," *‘Atiqot*, v. 57, 2007, pp. 73–76, 124–129, and 145–147. Gorin-Rosen and Katsnelson add the unpublished glass finds of Lod and Khirbat el-Faṭuna as secondary glass production sites of the late Roman–early Byzantine periods. For Apollonia-Arsuf, see Freestone, Jackson-Tal, and Tal [note 14]. Recently, evidence of secondary glass industries dating to the Byzantine period was reported to have been found also at Khirbat Jarrar (Yael Gorin-Rosen, "The Glass Finds," in Iskander Jabour, "Khirbat Jarrar," *Ḥadashot Arkheologiyot – Excavations and Surveys in Israel*, v. 116, 2004, p. 17*), Jatt (*idem*, "The Glass Finds," in Karem Sa‘id, "Jatt (B)," *Ḥadashot Arkheologiyot – Excavations and Surveys in Israel*, v. 116, 2004, p. 26*), and Ḥorbat Hermas (*idem*, "The Glass Vessels," in Ofer Sion, "Khirbat Hermas," *Ḥadashot Arkheologiyot – Excavations and Surveys in Israel*, v. 117, 2005 [http://www.hadashot-esi.org.il/index_eng.asp]; *idem*, "The Glass Finds from Ḥorbat Hermas," *‘Atiqot*, v. 51, 2006, pp. 34*–35* [in Hebrew; English summary, p. 236]; Yossi Elisha, "Ḥorbat Harmas," *Ḥadashot Arkheologiyot – Excavations and Surveys in Israel*, v. 119, 2007 [http://www.hadashot-esi.org.il/index_eng.asp]).

27. Mazor and Bar-Nathan [note 19]; Gorin-Rosen [note 19].

28. Weinberg, "A Glass Factory" [note 4].

29. Foy and Nenna [note 4], pp. 42–44; Amrein [note 9], pp. 87–94.

30. Foy and Nenna [note 4].

Chemical analysis shows that the glass from the workshop debris of Ramla (South) is typical of Byzantine-Islamic natron-type glass from the Levant. The vessels and the raw glasses have similar compositional ranges and present the same evidence of unusually extensive contamination by fuel ash. Assuming that the contamination of the chunks occurred during the primary glass-making process, it seems possible that all of the analyzed glass—chunks, vessels, and moils—came from a single contaminated tank of glass. This also suggests that the debris was produced during a relatively short period. From a chemical perspective, the Ramla (South) glass overlaps somewhat with the sixth- and seventh-century chunks from Apollonia-Arsuf and particularly with chunks and vessels from Beth Shean. This confirms the notion that stratigraphically secured late Byzantine and early Islamic glasses in Palestine display similar chemical compositions.

In the late Byzantine period, Ramla (South) was a satellite of nearby Lydda (Diospolis; Georgiopolis). Recent excavations in and around Ramla have also produced the remains of pottery kilns and other industrial activities that have not yet been investigated. This indicates that the two fire-dependent industries coexisted in the area. The location of these industries was carefully chosen: a rather elevated, sparsely inhabited area that was somewhat removed from the major administrative center it served. The pottery kilns were oriented along an east–west axis, with the firing area on the west side and the firing chamber on the east side. These conditions allowed the ceramic and glass artisans to utilize wood from the surrounding valleys and to make the best use of western sea winds.

The remains of the secondary glass production at Ramla (South) lack a furnace in situ and present a relatively small quantity of debris. However, construction in the upper occupation layer, dated to the eighth century, leveled (and thus destroyed) the entire late Byzantine occupation layer. Moreover, secondary glass production usually leaves poorer archeological traces than other fire-based industries because of the recycling of glass and the small and fragile nature of the furnaces.[31] There is archeological evidence that the late Byzantine occupation layer at Ramla (South) was abandoned sometime in the seventh century, and so it is possible that the furnace was dismantled by the artisans themselves.

Archeological and chemical analyses of the secondary glass workshop debris are an important addition to our understanding of the major role of glass production in Palestine. As in Apollonia-Arsuf and Beth Shean, the production of glass (both primary and secondary) was probably monitored by the central authority of that time, the church. It is no coincidence that glass production in Palestine is documented in major administrative centers and in nearby communities. The late Byzantine glass industry in Ramla (South) was the prelude to the flourishing glass industry of early Islamic Ramla, which has yielded numerous finds.

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31. *Ibid.*, p. 40.