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THE THOMAS PANEL

ROBERT H. BRILL AND DAVID WHITEHOUSE

THE THOMAS PANEL (Fig. 1) is an example of late Roman *opus sectile* wall decoration made of glass. The object, which is said to have been found in the Faiyum, 100 kilometers southwest of Cairo, was acquired by The Corning Museum of Glass in 1986. Part I of this paper (by D.W.) describes the panel and its parallels, notably the *opus sectile* panels from Kenchreai, the eastern port of ancient Corinth; Part II (by R.H.B.) describes laboratory investigations of the components of the panel and of comparable materials from Kenchreai. These investigations lead to the conclusion that the Thomas Panel and the Kenchreai panels almost certainly were made in the same place. It is probable, but not certain, that the place of manufacture was in Egypt.

PART I

THE PANEL AND ITS PARALLELS

Loose pieces apart, the Thomas Panel survives as a single fragment, 79.0 cm long.[1] The decoration consists of pieces of glass embedded in a resinous matrix that is backed with rectangular pieces of earthenware (Fig. 2). The glass includes 11 different colors or combinations of colors. The monochrome colors are red, yellow, brown, white (sometimes with a pinkish tint), and pink (all of these are opaque), and dark blue and greenish blue (both of these are translucent). There are canes of red with white, yellow with translucent green, and white with translucent purple; there are also pieces of gold sandwich glass in which the gold foil rests on colorless glass with a greenish yellow tint and is protected by a thin layer of almost completely colorless glass. Most of the pieces are between 0.2 cm and 0.3 cm thick, although the average thickness of the gold sandwich glass is 0.8 cm. The matrix varies in thickness between 1.5 cm and 3.0 cm. The earthenware supports, which measure approximately 28 cm by 8 cm, were fashioned from fragments of large, roughly cylindrical, wheel-thrown objects, perhaps amphorae or pipes.

Technique

In all probability, the panel was assembled in one of two ways.[2] According to the first alternative, the maker prepared a surface of the appropriate size with raised edges. Next, he laid the earthenware supports on the surface and covered them with the hot—hence softened—resinous substance that served as the matrix for the glass. Finally, he pressed the pieces of glass into the matrix, which on cooling became a rock-hard adhesive. The second alternative supposes that the first stage in the operation consisted of arranging the glass, which was then covered with the softened adhesive, into which the maker pressed the earthenware supports. This would have had two advantages over the first method: it would have allowed the mosaicist to compose the design at his leisure, without worrying about the matrix hardening as it cooled, and it would have insured that the decorated surface was flat.

1. Accession number 86.1.1.

2. Robert Scranton in Leila Ibrahim, Robert Scranton, and Robert Brill, *Kenchreai: Eastern Port of Corinth. II. The Panels of Opus Sectile in Glass*, Leiden, 1976, p. 2.

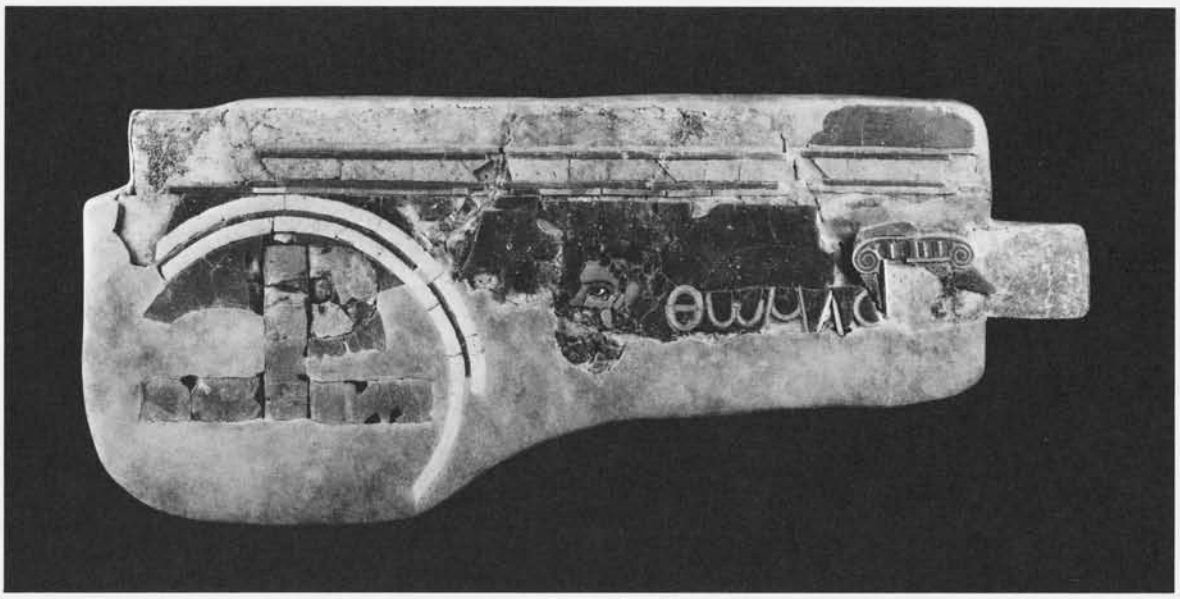

FIG. 1. *The Thomas Panel.*

Description

The fragment comes from the upper part of a square or rectangular panel, which presumably was once affixed to a wall. Part of the upper border survives. This consists of a broad red band above (in descending order) one narrow white and one narrow brown band, a broader yellow band, and one narrow red and one narrow brown band.

The ornament comprises a roundel, a bearded figure identified by an inscription as Thomas, and a column with an Ionic capital. The roundel has a triple border of yellow, red, and yellow circles. Inside the border, on a greenish blue background, is the Greek letter *rho*, made of at least two pieces of gold sandwich glass. Two detached rectangular pieces of gold sandwich glass may come from the roundel, in which case the motif was a *crux monogrammatica* (as shown in the restoration), rather than a *Chi-rho*.

To the right of the roundel, on a deep blue background, is a figure, presumably standing, of which only the head remains (Fig. 3). He is bearded and shown in profile, facing the roundel. The face is pink, the eyebrow and eyelid are brown, and the eye itself is brown and white. The hair consists of pieces of white and purple glass, as does the beard, the curls of which are indicated by canes with a spiral cross section. To the right of the figure, a Greek inscription in capital letters identifies him as Thomas (Fig. 4). In the penultimate letter, the crossbar, which ran from the bottom of the left side to the midpoint of the right side, is missing; its position, however, is clearly indicated by an impression in the resinous matrix. The final letter, detached when the panel was acquired, fits snugly into an impression in the matrix.

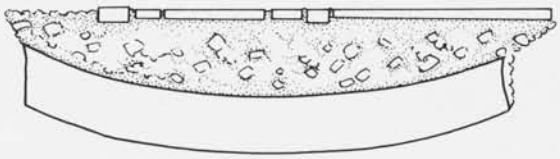

FIG. 2. *Section through part of the panel, showing the glass, the matrix, and one of the supports.*

To the right of the inscription are the remains of a column with an Ionic capital. The capital is outlined with a red cane at the top and a yellow cane

FIG. 4. *The inscription.*

FIG. 3. *The head of Thomas.*

at the bottom; the echinus consists of red rods alternating with yellow and green canes; each volute consists of a red and white cane that was reheated, pinned down at one end, and rotated to form a disk with a spiral pattern. The only surviving parts of the column are one brown and one yellow rod, arranged vertically.

At the far right edge of the fragment, still in position, is a small piece of deep blue glass.

Among the loose pieces acquired with the panel are part of an inscription containing the capital letters *nu* and *alpha*; a *beta*, a *sigma* (both capitals), and one other fragmentary letter, all in yellow; and a red and white volute from an Ionic capital. It seems unlikely, but it is not impossible, that a number of flat, pointed oval objects of white marble, which vary in length from 4.1 cm to more than 4.9 cm, come from the border of the panel. Two cuboid tesserae of white stone and a number of beads, on the other hand, are extraneous.

We may reasonably suppose that the roundel was placed at the center of a symmetrical design. It was flanked on either side, therefore, by a standing figure identified by a Greek inscription, beyond which was a column with an Ionic capital. The area of blue glass to the right of the surviving column shows that, when it was complete, the panel may have had at least one other motif or group of motifs between the column and the border.

The subject matter is explicitly Christian, but we have no means of identifying Thomas, who may be the apostle or some other saintly person of the same name. The panel, therefore, presumably adorned a church or chapel.

Parallels

Opus sectile panels, sometimes with figures, are known from a number of late Roman contexts. The most famous examples include the marble and glass panels from the basilica of Junius Bassus in Rome and the marble panels from Ostia.[3] The

3. G. Becatti, *Edificio con opus sectile fuori Porta Marina: Scavi di Ostia. VI*, Rome, 1967, pp. 181–215.

closest parallels for the Thomas Panel *entirely in glass* are from Kenchreai: more than 100 panels, adding up to more than 150 square meters of decoration. The subject matter is varied: pictorial compositions (Nilotic marsh scenes and architectural panoramas); standing figures, including consuls, poets (such as Homer and Theophrastus), and the philosopher Plato; and formal elements.

Despite clear differences—the Thomas Panel is Christian and contains gold sandwich glass; the Kenchreai panels are not, and do not—the two finds share a close family likeness. For example, both the Thomas Panel and the Kenchreai panels consist of pieces of glass of different shapes embedded in a resinous matrix and backed with rectangular pieces of earthenware, and in both cases the glass includes bichrome canes and highly unusual pink pieces employed for the faces and limbs of the figures.

From the beginning of our investigation, this family likeness suggested that the Kenchreai panels might provide an indication of the date and place of manufacture of the Thomas Panel. Both issues were addressed by the discoverer of the Kenchreai panels, Prof. Robert Scranton. The panels came to light in 1964 during excavations in the harbor area, in or near the Sanctuary of Isis.[4] They were found in the crates in which they had been, or were about to be, shipped. The crates were stacked against the walls of the so-called Fountain Court, and it was apparent that disaster had overtaken them before they could be removed or attached to the walls for which they were intended. The nature of the disaster was also apparent, for the buildings that contain the Fountain Court are partly submerged, with their floors tilted out of the horizontal plane, evidently by an earthquake. A coin of Valentinian I (364–378) seemed to show that the earthquake occurred in or after 364, and Scranton suggested that it may have been the event recorded by Ammianus Marcellinus and Zosimus as having occurred in 375; if this is correct, the panels were probably made at or shortly before that date.

In his discussion of the possible place of manufacture of the Kenchreai panels, Scranton drew attention to the mixed classical and Egyptian subject matter (notably the Nilotic scenes) and the mixed classical and Egyptian schema, the length of the friezes being in his view an Egyptian characteristic.[5] He also noted the Egyptian provenance of several other fragments of glass *opus sectile* panels: Antinoe, Nebesheh near Tanis, and Karanis in the Faiyum. Lastly, he reminded us of a passage in the *Historia Augusta*, which describes the career of the usurper Firmus, who established himself in Alexandria in 272. "Concerning his wealth," the passage reads, "it is said, for example, that he filled his house with square panels of glass set in bitumen and other substances." Scranton's conclusion, that "it remains a highly plausible hypothesis that the panels were made in Egypt," cannot at present be bettered. The reported provenance of the Thomas Panel and its similarity to the Kenchreai panels in style, in construction, and especially in the composition of the glass (described in Part II) suggest strongly that it, too, was made in Egypt.

PART II

Laboratory Studies

As Dr. Whitehouse has noted above, there is really only one significant parallel for the Thomas Panel: the group of some hundred *opus sectile* panels excavated at Kenchreai, the eastern port of ancient

4. Scranton [note 2], pp. 1–3. It should be noted, however, that a circular glass panel with an *opus sectile* border, discovered at Corinth in 1981, was found among the remains of a building that was destroyed by fire around the middle of the third century: Charles K. Williams II and Orestes H. Zervos, "Corinth, 1981: East of the Theater," *Hesperia*, v. 51, no. 2, April–June 1982, pp. 115–163, especially pp. 133–134 and pls. 42a and 43c.

5. Scranton [note 2], pp. 259–269. For the other finds, see Hans W. Müller, "Koptische Glasintarsien mit figurlichen Darstellungen aus Antinoe/Mittelägypten," *Pantheon*, v. 20, 1962, pp. 13–18; F. L. Griffith, "Gemaiyemi," in W. M. F. Petrie and F. L. Griffith, *Nebesheh: Tanis II*, London, 1886, pp. 39–40; Donald B. Harden, *Roman Glass from Karanis*, Ann Arbor, 1936, pp. 298–300, nos. 952–955. For the reference to Firmus: *Scriptores Historiae Augustae. Firmus, Saturninus, Proculus et Bonosus*, III, 2: "*De huius divitiis multa dicuntur. nam et vitreis quadraturis bitumine aliisque medicamentis insertis domum instruxisse perhibetur. . . .*"

Corinth.[6] These extraordinary panels have taught us most of what is presently known about *opus sectile* glass from the ancient world. It was natural, then, to turn to them as a background against which to carry out scientific and technological studies of the Thomas Panel, just as Dr. Whitehouse has done in his art historical and stylistic studies.

The starting point was the striking similarity of the ways in which the Thomas Panel and the panels from Kenchreai were constructed. In each case, small, flat pieces of brightly colored glasses, mostly opaque, were attached to earthenware "tiles" (probably broken from amphoras) by an adhesive matrix. Both also contain millefiori-like elements and canes, which clearly stemmed from the Ptolemaic and Roman traditions of richly colored glass ornamentation. The superficial resemblance is so strong that it begged for comparisons which would establish whether or not the Thomas Panel could have been made in the same workshop as the Kenchreai panels (this despite the marked iconographical differences and certain stylistic differences).

Five investigations were carried out:

1. Chemical analyses of the glasses.
2. Lead-isotope analyses of the glasses.
3. Identification of the components of the adhesive matrix.
4. Radiocarbon dating of the resin in the adhesive matrix.
5. Petrographic examinations, X-ray diffraction, chemical analyses, and other studies of the earthenware supports.

As it turned out, there are tantalizing small discrepancies, but overall, the Thomas Panel and the Kenchreai panels are far more *alike* than unlike, and these similarities must be taken into account in any attribution assigned to the Thomas Panel.[7] The evidence and interpretations which follow will undoubtedly sound very confusing—even to the careful reader. But what it all adds up to is that the Thomas Panel and the Kenchreai panels are inextricably bound together by several characteristics which imply that they were almost certainly made in the same place (or by the same people), of very similar materials, and by nearly identical methods, although not, perhaps, at the same time.

Chemical Analyses of the Glasses

Chemical analyses of 11 samples of the glasses, representative of the different colors, are reported in Table 1. Except for one truly remarkable finding, the compositions are about what one expects for late Roman glasses. All are soda limes with low potassium–low magnesium contents, indicating that they were made with natron and not with plant ash as their alkali.[8] Also, they contain manganese. The reduced compositions of the glasses,[9] which represent the base compositions without colorants and other additives, are also given in Table 1. Of the 10 quantitative analyses, six samples resemble one another very closely. They are Nos. 5451–5457 (excluding No. 5455, for which we have only a qualitative analysis). These six glasses could well have been made "in the same place at the same time."

The analyses of the two red opaques (Nos. 5458 and 5459) are almost identical. Although one is a flat piece and the other a drawn rod, they were almost certainly made from a single batch of red glass or red cullet. Their compositions differ significantly from those of the six glasses mentioned above, but it is difficult to decide if that is because

Acknowledgments. The author thanks Raymond F. Errett and Maxine G. Smith, both of The Corning Museum of Glass, for their assistance in sampling the glass and preparing the typescript of this article.

6. See note 2.

7. The one obvious physical difference is that the glasses in the Thomas Panel are only lightly to moderately weathered, while the glasses from Kenchreai are, with very few exceptions, very heavily weathered from their 16 centuries of immersion in water.

8. Robert H. Brill, "Scientific Investigations of the Jalame Glass and Related Finds," in *Excavations at Jalame, Site of a Glass Factory in Late Roman Palestine*, ed. Gladys Davidson Weinberg, University of Missouri Press, chapter 9. In press.

9. The reduced composition is the sum of the SiO_2, Na_2O, CaO, K_2O, MgO, Al_2O_3, and Fe_2O_3 normalized to 100%. See Brill [note 8] and Robert H. Brill, "Chemical Analyses of Some Early Indian Glasses," *Archaeometry of Glass, Archaeometry Session of the XIVth International Congress on Glass, New Delhi, 1986*, Calcutta: Indian Ceramic Society, 1987, section I, pp. 1–25.

TABLE I

Chemical Analyses of Thomas Panel Glasses

	clrls. *5450*	*lt. bl.* *opq.* *5451*	*dk. bl.* *opq.* *5452*	*pink* *opq.* *5453*	*wt.* *opq.* *5454*	*grn.* *5455*	*ylw.* *opq.* *5456*	*ylw.* *opq.* *5457*	*red* *opq.* *5458*	*red* *opq.* *5459*	*flesh* *5460*
SiO_2	67.7	69.0	70.3	71.5	70.3	76	58.0	63.4	58.0	57.3	68.4
Na_2O	21.6	18.6	18.6	17.6	17.9	15	13.1	16.5	13.8	12.3	16.5
CaO	5.60	5.63	5.88	5.81	6.50	3	4.61	5.77	6.47	6.24	6.63
K_2O	0.50	0.42	0.50	0.37	0.50	0.4	0.36	0.42	1.13	1.15	0.96
MgO	0.88	0.77	0.77	0.85	0.87	0.5	0.65	0.83	1.31	1.22	0.87
Al_2O_3	1.86	1.72	2.14	1.86	1.86	1.2	1.36	1.67	2.75	2.80	2.41
Fe_2O_3	0.59	0.66	0.88	0.64	0.78	0.9	0.57	0.71	2.39	2.58	1.21
TiO_2	0.10	0.12	0.10	0.09	0.08	0.2	0.10	0.08	0.25	0.25	0.15
Sb_2O_5	nf	nf	0.10	nf	nf	nf	0.25	nf	0.03	0.03	0.45
MnO	0.98	0.30	0.22	0.99	1.01	0.15	0.48	0.87	0.11	0.12	0.68
CuO	0.001	1.27	0.11	0.001	0.001	1.5	0.05	0.01	2.50	2.72	0.05
CoO	nf	nf	0.03	nf	nf	nf	nf	nf	0.01	0.01	nf
SnO_2	nf	0.75	0.01	0.10	0.005	0.20	2.89	1.12	0.80	1.11	0.98
Ag_2O	0.001	0.001	0.001	nf	0.001	0.005	0.005	0.001	0.001	0.001	0.15
PbO	0.01	0.55	0.21	0.07	0.04	1	17.6	8.52	9.56	11.1	0.45
BaO	0.04	0.05	0.03	0.03	0.05	0.05	0.05	0.03	0.02	0.02	0.03
SrO	0.05	0.03	0.05	0.04	0.05	0.02	0.03	0.05	0.05	0.05	0.05
Li_2O	0.001	0.001	0.001	0.001	0.001	nf	nf	0.001	0.001	0.001	0.001
B_2O_3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
V_2O_5	0.005	0.003	0.003	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
NiO	nf	nf	0.01	nf	nf	nf	nf	nf	0.05	0.05	nf
ZnO	0.012	0.090	0.014	0.010	0.008		0.015	0.009	0.79	0.91	0.018
ZrO_2	0.005	0.005	0.005	0.005	0.005	nf	nf	0.005	0.005	0.005	0.005
Au	nf	nf	nf	nf	nf	nf	nf	nf	nf	nf	0.003
SiO_2*d	68.6	71.3	71.0	72.5	71.2	78	73.7	71.0	67.5	68.6	70.5
Na_2O*	21.9	19.2	18.8	17.8	18.1	15.5	16.7	18.5	16.1	14.7	17.0
CaO*	5.67	5.82	5.93	5.89	6.58	3.1	5.87	6.46	7.54	7.46	6.84
K_2O*	0.51	0.43	0.50	0.38	0.51	0.4	0.46	0.47	1.32	1.38	0.99
MgO*	0.89	0.80	0.78	0.86	0.88	0.5	0.83	0.93	1.53	1.46	0.90
Al_2O_3*	1.88	1.78	2.16	1.89	1.88	1.2	1.73	1.87	3.21	3.35	2.49
Fe_2O_3*	0.60	0.68	0.89	0.65	0.79	0.9	0.73	0.80	2.79	3.09	1.25

Na_2O, CaO, K_2O, MgO, Al_2O_3, Fe_2O_3 by atomic absorption. Sb_2O_5, MnO, CuO, PbO (where greater than trace) also by atomic absorption. SiO_2 estimated by difference, significant to only three figures. All other oxides by emission spectrography. Analyses by B. A. Rising and R. Gonzales of Umpire and Control Services, Inc., West Babylon, N.Y.

No. 5455 qualitative spectrographic analysis only.

* Reduced composition; these seven oxides normalized to 100%.

they were made in a different factory or because of some difference in the chemistry of their manufacture. The lead-isotope analyses discussed below suggest that the latter is the case.

The compositions of the remaining two glasses, the gold glass and the flesh-colored glass, are discussed separately below. They border on differing significantly from the group of six glasses, and they also differ from each other. It seems likely that they were not made in the same place as the group of six glasses.

The colorants and colorant-opacifiers are also those expected for late Roman glasses.[10] The dark blue transparent glass is colored with cobalt and a little copper; the light blue opaque with copper and tin oxide; the yellow opaques, one with $PbSnO_3$, the other with $PbSnO_3$ and possibly also some $Pb_2Sb_2O_7$; and the red opaques with cuprous oxide in a high-lead matrix. The copper in the red opaques appears to have contained some nickel. The red opaques also contain substantial levels of tin (and of zinc)—somewhat more, perhaps, than just those which would have accompanied copper added as a bronze or brass derivative.[11] The single analyzed specimens of a white opaque (No. 5454) and a pinkish opaque (No. 5453) are a bit unusual. Chemical analyses and X-ray diffraction show that they are amorphous and do not contain either of the usual white opacifiers: calcium antimonate or tin oxide. Instead, they owe their opacity to being filled with innumerable seed and large bubbles.

The presence of zinc in the copper-containing glasses (Nos. 5451, 5458, and 5459) implies that the ingredient used to introduce the copper colorant was derived from a brass—one containing either zinc alone or both zinc and tin. This suggests, but does not prove, a somewhat late Roman date. Also, the use of the tin form instead of the antimony form of the yellow opacifier, and especially the use of tin oxide as a white opacifier (No. 5451), point toward dates later than the second century for the manufacture of the yellow and the light blue opaque glasses.[12] All these observations apply, even if the glasses were not made at the same time as the panels but instead were salvaged from mosaics or other earlier uses. If the glasses indeed had been salvaged from mosaics, those mosaics themselves must have been rather late. If the glasses were freshly made for the Thomas Panel, it is still quite plausible that they were produced in a factory where glass was made for mosaics.

As is true of most ancient opaques, the Thomas Panel glasses and the Kenchreai glasses are bubbly and filled with all sorts of stones and stray inclusions. This is probably a result of their having been reworked several times. The Thomas Panel glasses contain batch stones, devitrification stones, spherical metallic globules, flakes of metallic scale, and, usually near one flat surface or the other, fine terracotta colored inclusions probably picked up from a flattening surface.

Two minute globules of metal removed from specimens of red opaque glass were analyzed by Dr. Stephen S. C. Tong of Corning Glass Works, using an electron microprobe. The results are reported in Table 2. The hope was that these analyses might tell something about the composition of the parent material originally added as a colorant. As it turned out, however, the globules are less likely to be relict metal than simply copper precipitated out of solution by over-reduction. Perhaps the most interesting feature of the analyses is that small "islands" within one of the blobs consist mainly of copper sulfide. These had clearly once been molten, implying that the glass had been heated in excess of 1100°C (the melting point of cupric sulfide) during some late stage of its manufacture.

Regarding the palette of colors in the Thomas Panel, the gold glass is the only one which does not appear anywhere among the Kenchreai *opus sectile*

10. See Brill [note 8].

11. Robert H. Brill and Nicholas D. Cahill, "A Red Opaque Glass from Sardis and Some Thoughts on Red Opaques in General," *Journal of Glass Studies*, this volume.

12. For the use of antimony and tin colorant-opacifiers, see Robert H. Brill, "The Scientific Investigation of Ancient Glasses," *Proceedings of the VIIIth International Congress on Glass, London*, Sheffield, England: The Society of Glass Technology, 1968, pp. 47–68.

TABLE 2

Analyses of Metallic Inclusions

Cu	97.0	87	99.2
S	0.4	12	0.02
Zn	0.1	0.1	0.16
Sn	0.04	0.3	0.1
Pb	2.5	nf	0.4

Electron microprobe analyses by Dr. Stephen S. C. Tong of Corning Glass Works.

glasses.[13] It is noteworthy that the gold glass is much thicker than the rest of the glasses, and it looks as if it had been made from the same sort of starting blank as early Byzantine gold-glass tesserae. Also, as with those tesserae, the gold leaf is protected by a thin layer of colorless cover glass.

Two other aspects of the analyses, both of primary importance, remain to be discussed: the occurrence of gold in the flesh-colored glass and a comparison of the compositions with those of the Kenchreai panels.

The glass used for the face of the central figure is a very realistic and rare flesh-colored glass, one so rare, in fact, that many specialists in ancient glass may never have encountered it. We know of only two other occurrences. These are the flesh tones of the various human figures in the Kenchreai panels (Homer, Plato, Theophrastus, and the minor figures) and a fragment of a pink opaque skyphos in The Toledo Museum of Art.[14]

The chemical analysis of the flesh-colored glass in the Thomas Panel is reported in Table 1 (No. 5460). The reduced composition is not very different from those of the other Thomas Panel glasses, but it borders on not belonging with them. The alkali is lower, and the potassium and magnesium are slightly higher. More significantly, however, it contains a deliberately added level of antimony, while only two of the other Thomas Panel glasses contain antimony at greater than trace levels. (These are one of the yellow opaques, in which a minor level of antimony—0.25% Sb_2O_5—accompanies the tin in the yellow pigment phase, and the dark blue transparent, which contains 0.10% Sb_2O_5.) The 0.60% Sb_2O_5 in the flesh-colored glass may contribute to its opacity in the form of $Ca_2Sb_2O_7$, although the tin, in the form of SnO_2, probably also contributes to the opacity. The presence of both antimony and tin is puzzling, although not without precedent. For example, the flesh-colored glasses from Kenchreai also contain both. This may indicate that the flesh-colored glass was made by melting down older white opaques from two different sources.

What makes the flesh-colored glass so special, however, is the fact that it contains gold and silver. Although present in only minute traces (~0.003% or 30 p.p.m.), the gold is sufficient to confer a pinkish tint to the glass, just as it does to the three flesh-colored glasses analyzed from the Kenchreai panels, just as it does to the pinkish Toledo skyphos, mentioned above, just as it does to the pink color of a cut glass plate excavated in Axum,[15] and just as it does in conferring a transparent magenta color to dichroic diatreta.[16] Moreover, while intentionally added traces of gold (in combination with silver) are responsible for the color in these dozen or so glasses,[17] gold has never been detected in any of the

13. The pinkish canes are also an unusual color, but judging from their analyses, their pinkish cast results from oxidized manganese.

14. The Toledo Museum of Art No. 23.1377. In 1978, Dr. Kurt Luckner kindly provided a sample for chemical analysis.

15. This plate has an unusual bright pink color by transmission and a very slight greenish turbidity by reflectance. Described as Roman, it came from an undated context in Axum, Ethiopia. Our sample, provided by Ato Mamo Tessema in Addis Ababa in 1973, was found to contain 0.001% gold and 0.008% silver. Its base composition closely resembles that of the dichroic diatreta mentioned in note 16. Mrs. Helen Morrison will include the results of our analysis in a forthcoming publication on the finds from Axum.

16. Robert H. Brill, "Cage Cups: Chemical Analyses and Their Implications," A Colloquium on Roman Glass, The Corning Museum of Glass, April 24, 1987.

17. During experiments in reproducing the Lycurgus Cup dichroism years ago, we inadvertently produced glasses with a translucent color closely resembling the flesh-colored *opus sectile* glasses. The colorant was colloidal gold and silver at concentrations comparable to those in No. 5460.

some 1,500 other ancient glasses analyzed by The Corning Museum of Glass.[18] The base glass compositions of the above examples vary somewhat (particularly in the lead content of the skyphos), but what really counts is what they have in common: they all contain gold and silver.

Because the *opus sectile* glasses are linked to the dichroic diatreta and the other two luxury glasses by this extraordinary chemical factor, it seems to us that they must also be linked by some cultural factor—perhaps a family of glassmakers who had a hand in making all of them. Except for the skyphos, which is earlier, late third- to mid-fourth-century dates are quite reasonable for all the glasses involved.

Regarding comparisons between the Thomas Panel compositions and those from Kenchreai, the latter had one curious feature.[19] The Kenchreai red opaques were made in one place (somewhere where plant ashes were used as a source of soda), while all the other colors were made elsewhere (someplace where natron was used). This lent support to the notion that the glasses had been salvaged from mosaics in different locations. The situation is not quite the same with the Thomas Panel glasses. Although the red opaques differ from the other colors (having higher potassium and magnesium contents), the differences are nowhere near as striking as they are in the Kenchreai glasses, and we concluded above that the red opaques were probably made in the same place as the other colors. Moreover, the Kenchreai glasses (*excluding* the red opaques) were divided into two slightly different compositional groups, characterized, among other things, by whether or not they contained antimony. Mean compositions of those two groups and of the six glasses representative of the Thomas Panel are given in Table 3.

From graphical comparisons of these three mean compositions, and particularly from plots of the most critical pairs of oxides,[20] the Thomas Panel glass appears to be almost a composite of the two types of Kenchreai glass. This finding is consistent with the hypothesis that the glass in the Thomas Panel was originally made in the same place as the Kenchreai glasses, although not necessarily at the same time. It is especially interesting that the flesh-colored glass from the Thomas Panel (No. 5460), which contains some antimony and which differs slightly from the other Thomas Panel glasses, does, in fact, match quite well the three flesh-colored glasses analyzed from the Kenchreai panels. (These are included in the antimony-containing Kenchreai glasses listed in Table 3.) Chemically, at least, they seem to have been made in the same place.

Lead-Isotope Analyses

Isotopic analyses of lead extracted from ancient objects can be used to determine which mining regions the leads could have come from and which they could not have come from. Consequently, these analyses are also useful for learning more about where the objects themselves might have been made.[21] Therefore, lead-isotope analyses of

18. Actually there is one exception: a large cast and cut head of an eagle (CMG analytical sample No. 4999). Although there are several good reasons for believing it is Achaemenian and made in Iran, it could possibly be modern. This glass, black in appearance, contains about 0.002% gold, which gives it an icy-blue color, with some brownish back-scattering, when viewed in thin sections. A soda-lime glass, it contains an elevated level of boron characteristic of certain ancient glasses made in Iran and parts of Turkey.

19. See note 2.

20. Na_2O^* *vs.* CaO^*, K_2O^* *vs.* MgO^*, and $Fe_2O_3^*$ *vs.* $Al_2O_3^*$.

21. For more about the method and its application to glasses, see Robert H. Brill, "Lead Isotopes in Ancient Glass," *Proceedings of the IVth International Congress on Glass, Ravenne-Venise*, Liège: International Congress on Glass, 1969, pp. 255–261; Robert H. Brill, "Lead and Oxygen Isotopes in Ancient Objects," *The Impact of the Natural Sciences on Archaeology*, London: The British Academy, 1970, pp. 143–164; Robert H. Brill and William R. Shields, "Lead Isotopes in Ancient Coins," *Special Publication No. 8*, Royal Numismatic Society, Oxford: University Press, 1972, pp. 279–303; Robert H. Brill, I. Lynus Barnes, and Barbara Adams, "Lead Isotopes in Some Ancient Egyptian Objects," *Recent Advances in Science and Technology of Materials*, v. 3, New York and London: Plenum Press, 1974, pp. 9–27; Robert H. Brill, "The Usefulness of Lead-Isotope Studies as Illustrated by Investigations of Ancient Glass," *The Archaeological Institute of America*, Abstract of the 79th General Meeting, Atlanta, Georgia, December 28–30, 1977, p. 37; Robert H. Brill, Stephen S. C. Tong, I. Lynus Barnes, Emile C. Joel, and Martin J. Murtagh, "Laboratory Studies of Some European Artifacts Excavated on San Salvador Island," *Proceedings, First San Salvador Conference,*

TABLE 3

Comparison of Thomas Panel and Kenchreai Glasses
(Mean reduced values and 90% confidence limits)

	Thomas Panel			*Kenchreai*					
				with antimony			*no antimony*		
		(n = 6)			*(n = 12)*			*(n = 9)*	
		$\bar{x}$			$\bar{x}$			$\bar{x}$	
SiO_2*	*69.9*	71.6	*73.3*	*68.0*	70.6	*73.3*	*66.5*	68.8	*71.2*
Na_2O*	*16.7*	18.2	*19.6*	*15.8*	17.7	*19.6*	*18.8*	19.9	*20.9*
CaO*	*5.51*	6.08	*6.65*	*5.79*	6.57	*7.35*	*5.69*	6.54	*7.39*
K_2O*	*0.37*	0.46	*0.55*	*0.49*	0.71	*0.93*	*0.29*	0.40	*0.51*
MgO*	*0.77*	0.85	*0.94*	*0.68*	0.96	*1.24*	*0.71*	1.04	*1.37*
Al_2O_3*	*1.72*	1.82	*1.93*	*1.58*	2.30	*3.02*	*1.51*	1.95	*2.39*
Fe_2O_3*	*0.62*	0.73	*0.84*	*0.85*	1.12	*1.39*	*0.33*	1.09	*1.85*

Kenchreai samples do *not* include the plant ash-based red opaques.

Thomas Panel samples: Nos. 5451, 5452, 5453, 5454, 5456, 5457 were used for calculation. No. 5452 was omitted from calculations of Al_2O_3* and Fe_2O_3*.

six specimens of the Thomas Panel glasses were carried out. Similar analyses had previously been made of 14 glasses from the Kenchreai panels.[22] The analyses of both groups of glasses were supervised by Dr. I. Lynus Barnes of the National Bureau of Standards, Gaithersburg, Maryland. Ms. Emile Joel, an employee of the Conservation Analytical Laboratory of the Smithsonian Institution, ran the analyses of the Thomas Panel glasses at the Bureau. The results are reported in Table 4.

The Kenchreai panels had yielded especially interesting findings. Seven of the eight glasses with lead-antimony or lead-tin colorant-opacifiers fell within an isotope range which is quite common among all sorts of ancient lead-containing materials. This range is within the Group X type of lead, which contains dozens of objects found in, or associated with, archeological sites in Italy, the Levant, and Egypt. Significantly, however, the six Kenchreai red opaques analyzed were distinctly different, forming a tight cluster at the edge of Group E and closely matching several leads found in objects from the environs of Constantinople. Very clearly, the leads in the Kenchreai red opaques came from a different mining region than did the leads in the other colors of Kenchreai glass. This finding correlated with the differences (noted above) in the chemical compositions of the red opaques *versus* the other colors. We concluded that the Kenchreai panels could have been made up of glasses salvaged and recycled from mosaics made in different regions. Also, because there was a spread of values among the glasses other than the red opaques, it appeared that the lead-antimony and lead-tin pigments had been prepared in a place where different isotopic types of lead were commonly in use, that is to say, a place remote from any single lead mining region.

In one sense, the results of the Thomas Panel isotope analyses resemble those for the Kenchreai panels, but in another sense, they are different. Four of the Thomas Panel glasses—the two red opaques, the green, and one of the yellow opaques—are very similar to one another, and they are bracketed by

Columbus and His World, College Center of the Finger Lakes, Bahamian Field Station, 1987, pp. 247–292; and Brill [note 9].

22. See note 2.

TABLE 4

Lead-Isotope Analyses

Sample No.	*Chemical Analysis No.*	*Color*	$^{207}Pb/^{206}Pb$	$^{208}Pb/^{206}Pb$	$^{204}Pb/^{206}Pb$
Pb-2125	5456	Ylw. opq. (Sb, Sn)	0.83166	2.06096	0.053029
Pb-2128	5460	Flesh (Sb, Sn)	0.833107	2.06337	0.053185
Upper limit Group L		–	0.8340	–	–
Lowest Kench. ratio (GroupX)		Ylw. opq. (?)	0.8347	–	–
Pb-2126	5455	Grn. trans. (Sn)	0.836652	2.07188	0.053405
Pb-1149	3527	Flesh, skyphos	0.836857	2.07498	0.053415
Pb-2120	5458	Red opq. (Sn)	0.836934	2.07176	0.053453
Pb-2121	5459	Red opq. (Sn)	0.837226	2.07287	0.053446
Pb-2123	5457	Ylw. opq. (Sn)	0.838550	2.07458	0.053599
Highest Kench. ratio (Group X)		Flesh (Sb, Sn)	0.8403	–	–
Lowest Kench. ratio (Group E)		Red opq.	0.8421	–	–
Highest Kench. ratio (Group E)		Red opq.	0.8439	–	–

All analyses were performed at the National Bureau of Standards, Gaithersburg, Md., under the supervision of I. Lynus Barnes. The Thomas Panel samples were analyzed there by Emile Joel, an employee of the Conservation Analytical Laboratory of the Smithsonian Institution.

the "Group X" glasses from Kenchreai. We conclude that these four glasses from the Thomas Panel, including the two red opaques, were all made in the same place—possibly the same place that produced the non-red glasses from Kenchreai. Interestingly, the lead in the Toledo skyphos is also almost identical, isotopically, to this same group.

The other two glasses from the Thomas Panel (Pb-2125 and Pb-2128) contain a different kind of lead: Type L from the Laurion mines in Greece. These are also the only two glasses analyzed which definitely contain intentionally added antimony.

One interpretation of these results is that the Thomas Panel glasses were made in at least two different places and put to some initial uses. Later, they were salvaged and somehow brought together to be recycled and formed into the components eventually used to make the Thomas Panel and whatever other panels it accompanied. One of the original places of manufacture could well have been the same location where the Kenchreai non-red glasses were made, but the other was a place where Laurion lead was used for preparing the lead-antimony pigment. One probable candidate for the latter site is Egypt. Along with the Rhodes bead factory,[23] Egypt is the only place, to our present knowledge, where Laurion lead was probably used for preparing the yellow pigment to be incorporated into natron-made glasses during Hellenistic or Roman times. One of these glasses, Pb-2125, is a yellow opaque; the other, Pb-2128, is the flesh-col-

23. Gladys D. Weinberg, "A Hellenistic Glass Factory on Rhodes—Progress Report," *Journal of Glass Studies*, v. 25, 1983, p. 37; *idem*, "Glass Manufacture in Hellenistic Rhodes," *Archaiologikon Deltion*, v. 24, 1969, pp. 143–151.

ored glass. The flesh-colored glasses of the Kenchreai panels do *not* contain Laurion-type lead, but instead are among the other non-red Kenchreai glasses of Group X.

The Adhesive Matrix

The adhesive matrix which holds the glass in place, and bonds it to the earthenware supports, resembles, in its appearance, the corresponding material in the Kenchreai panels. Indeed, upon chemical examination, the two proved to be, for all practical purposes, identical.[24]

Small samples of the adhesive matrix were subjected to two treatments in order to separate the organic and inorganic phases. The same treatments had proven successful with Kenchreai samples previously. One sample was treated with warm, dilute hydrochloric acid. The acid dissolved the inorganic phases entirely and with vigorous effervescence, leaving a soft, gummy mass of a resinous substance which, at a temperature of about 75–80°C, coagulated and could be collected nicely as a wad on the tip of a glass stirring rod. Upon cooling, the material broke up into brittle, porous, dark brown lumps which were identified as the same pine resin (rosin or colophony) as had been used in making the Kenchreai adhesive matrix.

Another portion of the original Thomas Panel sample was treated several times with warm carbon tetrachloride until the organic phase (the rosin) was completely dissolved. The resulting liquid was filtered and the residue washed repeatedly to recover the insoluble inorganic phases. Upon drying, these proved to be mainly small chips or granules of marble and finely pulverized marble. Evaporation of the filtrate yielded a shiny, brittle, dark amber colored powder with the characteristic odor and tacky touch of rosin.

The extractions described above were not carried out quantitatively, but three separate estimates suggest that the mixtures varied in composition between about 15% and 25% rosin, with the remainder being small marble chips and marble dust. The adhesive matrix from the Kenchreai panels contained about 20% rosin. Chemical analyses of the marble (Table 5) showed it to be quite similar to the corresponding inorganic phases from the Kenchreai panels.

TABLE 5

Chemical Analyses of the Inorganic Phases in Adhesive Matrices

	The Thomas Panel	*Kenchreai Panels*	
	Grains and powder	*White marble*	*Gray marble*
	5483	*794*	*795*
$CaCO_3$	92.8	95.3	95.3
$MgCO_3$	2.57	2.21	1.71
Al_2O_3	1.08	0.0x	0.x
SiO_2		0.1	0.1
Na_2O	0.31	0.0x	0.0x
K_2O	0.28		
Fe_2O_3	0.36	0.01	0.x
MnO_2	0.01	0.0005	0.01
SrO	0.02	0.05	0.05
TiO_2	0.08	0.001	0.01
B_2O_3	0.001	0.001	0.001
CuO		0.0005	0.0005
PbO	0.005	0.001	0.001

Calcium and magnesium were determined by atomic absorption and are reported as carbonates. Other metals reported to two or three significant figures were also determined by atomic absorption and are arbitrarily reported as the oxides. All other metals were estimated by emission spectrography.

Analyses by Dr. Brandt A. Rising and Mr. Roland Gonzales, formerly of Lucius Pitkin, Inc., now at Umpire and Control Services, Inc., West Babylon, N.Y.

Samples of the resin recovered from both extractions were submitted for radiocarbon dating. As a control, a sample of resin from the Kenchreai panels which had been run in 1973 was rerun with the Thomas Panel samples. The results are reported in Table 6.

24. See note 2.

TABLE 6

Radiocarbon Dates of Resins*

Sample	*Source*	*Normalized Apparent Date*	*Most Probable Date***
5480	Thomas Panel (HCl)	385 A.D.	
			410 A.D. ± 115
5481	Thomas Panel (CCl_4)	435 A.D.	
F	Kenchreai (1973)	335 A.D.	
			350 A.D. ± 85
F	Kenchreai (1987)	365 A.D.	

* Measurements by James Buckley of Teledyne Isotopes, Westwood, N.J.
** 90% confidence limits.

TABLE 7

Analyses of Earthenware Supports

	Thomas Panel	*Kenchreai*			
	5468	*4621*	*4625*	*4626*	*4627*
SiO_2	~68.7	~72.4	~63.8	~61.8	~60.2
Na_2O	0.64	0.88	0.40	0.40	0.36
CaO	11.8	7.74	11.3	13.3	15.9
K_2O	1.75	1.48	1.56	1.52	1.91
MgO	1.11	1.53	1.53	1.45	2.91
Al_2O_3	11.8	11.8	16.0	16.0	13.4
Fe_2O_3	3.54	3.59	4.78	4.78	4.63
TiO_2	0.50	0.40	0.50	0.60	0.50
MnO	0.024	0.026	0.033	0.036	0.057
CuO	0.003	0.003	0.003	0.003	0.003
Ag_2O	<0.001	<0.001	<0.001	<0.001	<0.001
PbO	0.005	0.010	0.005	0.005	0.001
BaO	0.03	0.08	0.03	0.03	0.03
SrO	0.05	0.03	0.03	0.05	0.05
Li_2O	0.005	0.001	0.005	0.005	0.003
Rb_2O	0.02	0.01	0.01	0.01	0.01
B_2O_3	0.01	0.01	0.01	0.01	0.01
V_2O_5	0.005	0.005	0.005	0.005	0.005
Cr_2O_3	0.005	0.005	0.005	0.005	0.005
NiO	0.005	0.005	0.005	0.005	0.005
ZnO	0.020	0.017	0.021	0.021	0.021
ZrO_2	0.01	0.01	0.01	0.01	0.01

Data are arbitrarily reported as oxides.
Na_2O, CaO, K_2O, MgO, Al_2O_3, Fe_2O_3, MnO, ZnO by atomic absorption.
SiO_2 estimated by difference.
All others by emission spectrography.
Also sought but not found: Sb, Co, Bi, As, Sn.
Analyses by B. A. Rising and R. Gonzales of Umpire and Control Services, Inc., West Babylon, N.Y.

Because the samples from the Thomas Panel (Nos. 5480 and 5481) were quite small, the uncertainties in the measurements are larger than normal for radiocarbon dates. The results establish, however, that the resin in the Thomas Panel dates from about A.D. 410, plus or minus 115 years, at a 90% confidence level. Similar dating of the resins from the Kenchreai panels gave a date of A.D. 360, plus or minus 80 years. Overall, the findings verify that the Thomas Panel and the Kenchreai panels are at least roughly contemporaneous, and they hint that the Thomas Panel could have been made two to eight decades after the panels from Kenchreai, but probably not before them.

The Earthenware Supports

The earthenware supports of the Thomas Panel look much like those from the Kenchreai panels, and their dimensions are about the same. The one significant difference in shape is that the Thomas Panel supports have considerably greater radii of curvature—great enough, in fact, to make it doubtful that they came from amphorae.

Several types of analyses have been carried out in hopes of determining whether the supports from the Thomas Panel and those from Kenchreai could have come from the same source or if they must have come from different sources. Bulk chemical analyses are reported in Table 7. Such analyses of small numbers of samples are not a very sound way of classifying pottery. Major and minor component levels can be quite variable owing to the heterogeneity of most samples. Nevertheless, on the basis of major and minor elements, the Thomas Panel sherd is a reasonably good match for the four Kenchreai sherds analyzed, and on the basis of trace elements, it is a very close match.

Samples of three sherds were submitted to Prof. D. P. S. Peacock of the University of Southampton. He passed them on to Mr. David Williams for petrographic examination. Mr. Williams's findings suggest that the two Kenchreai sherds he examined could have come from North Africa, possibly central Tunisia. However, the fabric and texture of the single Thomas Panel sherd he examined were not familiar to him, and he could not suggest an origin. His comments are included in Appendix I.

On the other hand, X-ray diffraction analyses and scanning electron micrographs by Mr. Martin Murtagh of Corning Glass Works indicate that the clays used for making both the Thomas Panel sherds and the Kenchreai sherds probably came from a single source. Mr. Murtagh's report is attached here as Appendix II. It is hoped that further investigations of the sherds, or further interpretations of the existing data, may cast more definitive light on the relationships—or lack of relationship—between the Thomas Panel and its famous antecedents.

APPENDIX I

Note on the Petrology of Amphorae Fragments Used to Back the Thomas and Kenchreai Panels

David Williams
Department of Archaeology
University of Southampton

Three small fragments of amphora wall were submitted for a detailed fabric examination in thin section under the petrological microscope, the object being to try to identify the type and provenance of amphorae that were used to back the panels.

1. CMG 5468. Support from the Thomas Panel.

The thin section shows frequent subangular grains of quartz ranging in size up to 0.80 mm across, together with fragments of limestone, some foraminifera, shell, a few flecks of mica, and several pieces of moderately coarse sandstone. This fabric and texture are not known to the writer, and no useful suggestion can be made at present about the form of amphora represented here or its likely origin.

2. CMG 4625. From Kenchreai, about A.D. 365.

3. CMG 4626. From Kenchreai, about A.D. 365.

Both sherds appear very similar when viewed under the petrological microscope, and they con-

tain the typical quartz-limestone inclusions and texture associated with the cylindrical amphorae of North African origin. In this case, the texture suggests a central Tunisian origin, and the form probably belongs to one of the types illustrated by D. P. S. Peacock and D. F. Williams, Classes 33–35 (*Amphorae and the Roman Economy*, London, 1986). North African amphorae were made over a long period of time, with production certainly lasting into the sixth century A.D. These vessels are generally thought to have carried olive oil, though fish products may also have been carried to a lesser extent.

APPENDIX II
Laboratory Examinations of the Thomas Panel and Kenchreai Earthenware Supports

M. J. Murtagh
Corning Glass Works
Corning, New York

Four sherds, three from the Kenchreai panels (Nos. 4621, 4622, and 4625) and one from the Thomas Panel (No. 5468), were submitted for laboratory examination. The following analyses were carried out: powder X-ray diffraction (XRD), mercury porosimetry, scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS). The purpose of these analyses was to compare supports from the Thomas Panel and those of the Kenchreai panels to see if they could have been made in the same place.

The XRD analysis established that all four samples contain similar mineral assemblages. The major mineral phases found were quartz and calcite, with minor phases of illite, anatase, and rutile. The anatase and rutile varied among the samples. (Nos. 4621 and 4622 had both anatase and rutile, No. 4625 had only rutile, and No. 5468, from the Thomas Panel, had only anatase.) The results of the mercury porosimetry revealed differences in the percent wall porosity. The Kenchreai sherds had the lower wall porosities (Nos. 4621 and 4622 = 14%, 4625 = 10%), while the Thomas sherd was higher (No. 5468 = 24%). This difference is primarily due to firing variability, as indicated by the variations in the presence of anatase and rutile. (Anatase converts to rutile at temperatures greater than or equal to 900°C.) The micrographs shown in Figure 5 illustrate the distribution of quartz and calcite. The quartz appears to have been added as temper. Shown in Figure 6 are laths of illite, the ideal composition of which is $K_6Al_2(Al_{1-y}Si_{3+y}O_{10})(OH)_2$, along with a supporting EDS analysis. The presence of the clay mineral illite in all the sherds shows that the firing temperatures were below 1050°C. It might also be possible to use the illite as an indicator of the type of geological horizon from which the clays originated.

Based on the analyses described, the Thomas Panel support shows more similarity than dissimilarity to the supports of the Kenchreai panels. The XRD results are the most conclusive, as indicated by the similarities in both the major and minor mineral assemblages of all the sherds examined. The utilization of X-ray diffraction in this study was most effective in resolving the illite, which escapes absolute detection and, therefore, classification petrographically. The porosimetry and microscopy results revealed textural differences (i.e., in pore volume and surface hardness), those differences are explained by firing variability. Therefore, this author believes that the supports of the Thomas Panel were made of clays having the same geological makeup as the clays used for the supports of the Kenchreai panels. However, this does not mean that they necessarily came from the same location, only that the locations from which they came were very similar geologically.

Sample Descriptions

5450

Colorless glass, with gold leaf encased by thin layer of colorless cover glass. From thick fragment used for monogram. (Sample contains no gold leaf.)

5451

Light blue opaque glass; flat inlay.

Brill, Robert H., and David Whitehouse. "The Thomas Panel." The Journal of Glass Studies vol. 30 (1988): 34-50.

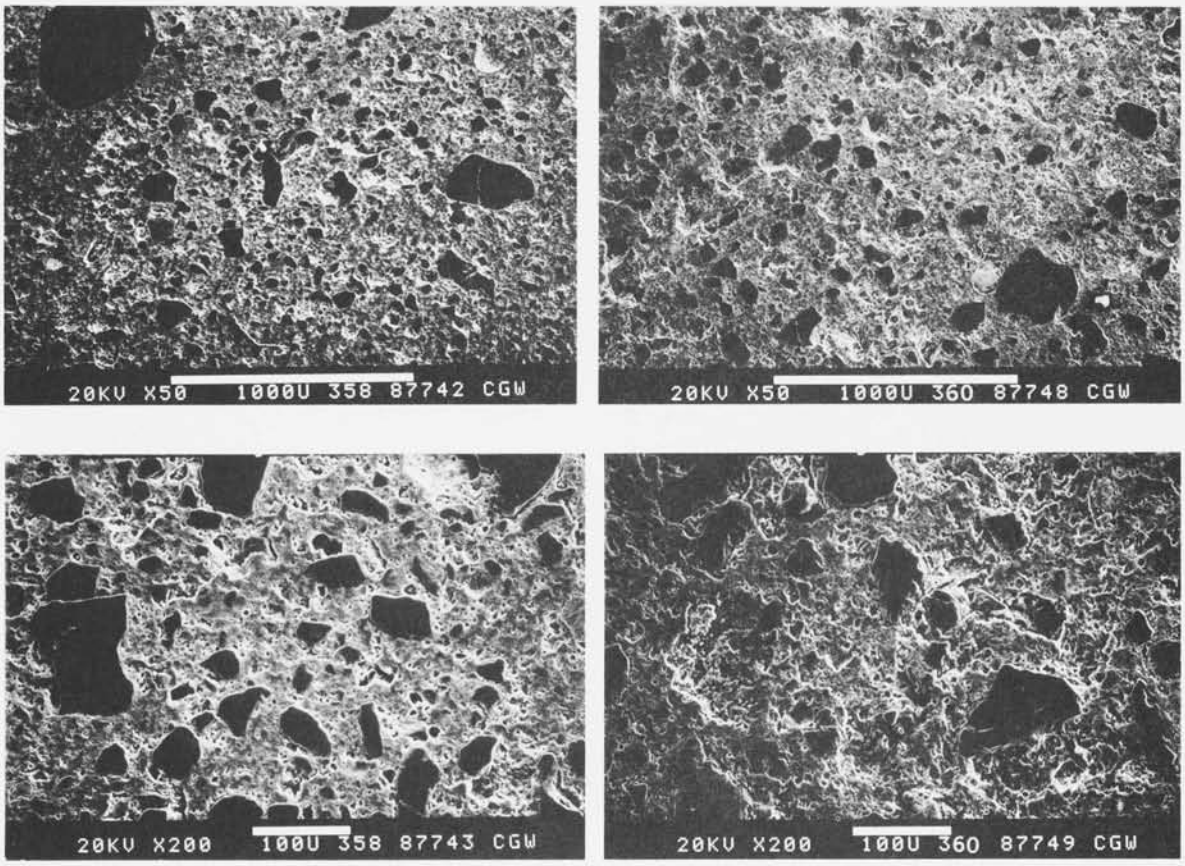

FIG. 5. *Scanning electron micrographs of Kenchreai panel support 4621 (left) and Thomas Panel support 5468 (right), showing the distribution of quartz and calcite in the clay matrices.*

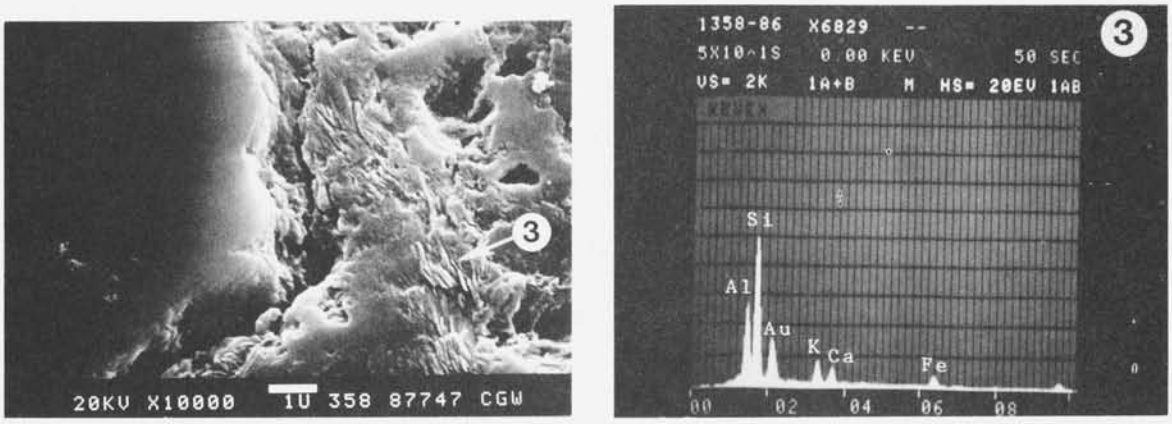

FIG. 6. *Scanning electron micrograph of Kenchreai panel support 4621, showing laths of illite in the clay matrix (arrow) and supporting EDS analysis.*

5452
Dark blue transparent glass; flat inlay.

5453
White opaque glass with pinkish tint, very bubbly; border cane.

5454
White opaque glass, very bubbly; flat inlay.

5455
Green transparent glass; flattened ribbon-like inlay with yellow opaque fused on.

5456
Yellow opaque glass, from same fragment as 5455.

5457
Yellow opaque glass; flat inlay.

5458
Red opaque glass; flat inlay.

5459
Red opaque glass; border cane.

5460
Flesh-colored glass; flat inlay.

5468
Earthenware support.

5469
Earthenware support.

5470
Earthenware support.

5478
Metallic globule, nearly spherical, coppery in color. Diam. ~0.8 mm. From interior of 5458.

5478A
"Island" inside 5478, apparently once molten.

5479
Metallic globule, nearly spherical, coppery in color. Diam. ~0.6 mm. From interior of 5459.

5480
Resin residue from hydrochloric acid extraction.

5481
Resin recovered from carbon tetrachloride extraction.

5483
Insoluble residue from carbon tetrachloride extractions. Granular material combined with fine powdery material.

Pb-2120
Red opaque glass. (Same as 5458.)

Pb-2121
Red opaque glass. (Same as 5459.)

Pb-2123
Yellow opaque glass. (Same as 5457.)

Pb-2125
Yellow opaque glass. (Same as 5456.)

Pb-2126
Green transparent glass. (Same as 5455.)

Pb-2128
Flesh-colored glass. (Same as 5460.)