

## A collaborative study of early glassmaking in Egypt c. 1500 BC

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Our study of early glass was begun when we discovered that Metropolitan Museum objects from the tomb of three foreign wives of Tuthmosis III in the Wadi Qirud at Luxor had many more vitreous items than had been thought during the last 60 years. Not only was there a glass lotiform vessel (fig. 34)<sup>1</sup>, but two glassy vessels (fig. 10), and many beads and a great amount of inlay of glass (figs. 36-40). As it became apparent that half of the inlays had been colored by cobalt (that rare metal whose provenance in the 2nd millennium BC is still a mystery), and when the primary author realized that most of the Egyptian glass studies published up to then had used 14th/13th century BC or poorly dated samples, rather than 15th century BC or earlier glass, a collaborative project was begun at The Metropolitan Museum of Art and The Corning Museum of Glass. The first goal was to build a corpus of early dated glasses, compositionally analyzed.

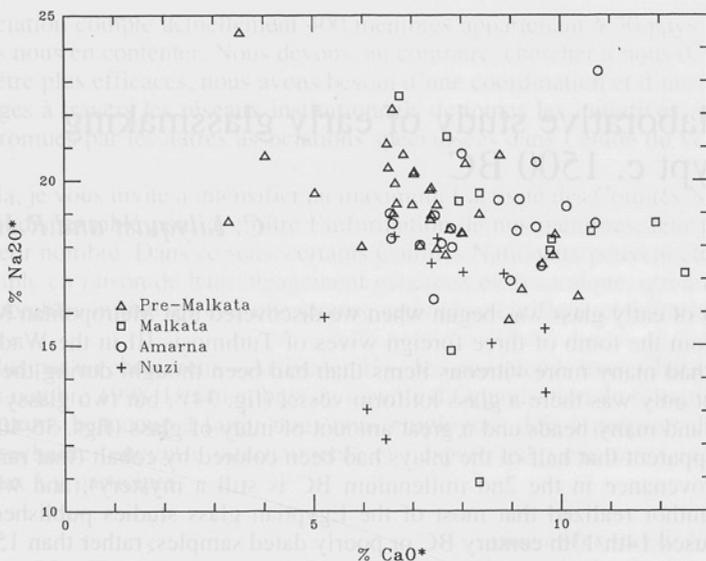
As we proceeded, we therefore decided to explore glassy materials contemporary with, or earlier than, our "pre-Malkata Palace" glasses as we called them (i.e., pre-1400 BC; figs. 1, 3-5, 7-9). Our purpose was to see if there were relationships that would suggest whether early Egyptian glass had come out of the native vitreous industry, or whether it had arrived through connections with western Asia. A faience factory in late Old Kingdom-First Intermediate Period levels at Abydos (ca. 2300-2000 BC) — excavated recently by the University of Pennsylvania — indicates that, in Egypt, faience was made locally for private use, no matter what the state of national government. Also, at 13th Dynasty Lisht — another low period of political organization — the crocodile in figs. 1 and 4 was made of a material intermediate between Egyptian Blue and glassy faience. But at some point, the creative leap was made to another level of vitreous technology (i.e., glassmaking), and we were interested in finding information on that step.

A cornerstone of this study, therefore, was the consideration of all types of glassy objects — not just vessels, but beads, scarabs, pins, and small sculpture — thinking that only by including them could we begin to track variety and change in vitreous technology.

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This paper discusses the results of a project published two years ago: Lilyquist & Brill 1993. The key points will be discussed here, as well as issues that have gained more importance since the project was finished. Citations refer to that publication. *Figs. 1-5* here correspond with figs. 50, 52, 58, 60 and 51 in Lilyquist & Brill 1993.

<sup>1</sup> These non-italic figures refer to Lilyquist & Brill 1993.



1. Normalized sodium and calcium oxide contents for all glasses, showing variation in calcium.

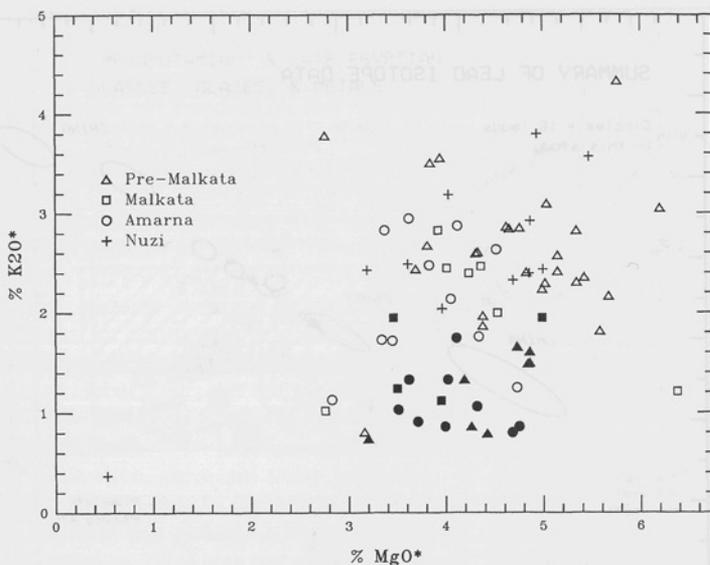
Indeed, this approach seems to have paid off; for we found glass in Palestinian-style pendants from the tomb of Ahhotep (figs. 21-22), late Dynasty 17 in Egypt. This is exactly the period when the Palestinian Hyksos in Egypt were being driven out of the Nile Delta by the southern, Theban-based Egyptians. And by analyzing one of these pendants in the Metropolitan Museum, we were also able to suggest that one of the two colors used must have been cobalt<sup>2</sup>.

Looking at small objects, we were also able to document glass as the copper-colored wire-wrapped material of beads found with Palestinian-style Bichrome pottery in Egypt, from a site between the Hyksos and Upper Egyptian capitals (fig. 25). Glass beads and inlays in Palestinian-style jewels from Megiddo would have preceded or been contemporary with the Ahhotep pendants<sup>3</sup>.

With a foreign element called to mind, it then became possible to see features in the famous British Museum juglet with Tuthmosis III's name (fig. 43) that came out of the east Mediterranean: striped handle, dots, plants, and ring foot all appear on Middle Bronze II/Late Bronze I items (figs. 41-42, 44). Even a fragment from the tomb of Tuthmosis III (fig. 19, upper left) — with its beautiful turquoise ground and yellow triangles — could be seen with Near Eastern eyes. This author had first

<sup>2</sup> A few of the inlays in an Egyptian-style pectoral from the same tomb (fig. 23) illustrate that it didn't take long for glass to be made in Egyptian style.

<sup>3</sup> Lilyquist 1993, figs. 17, 25d, 28.

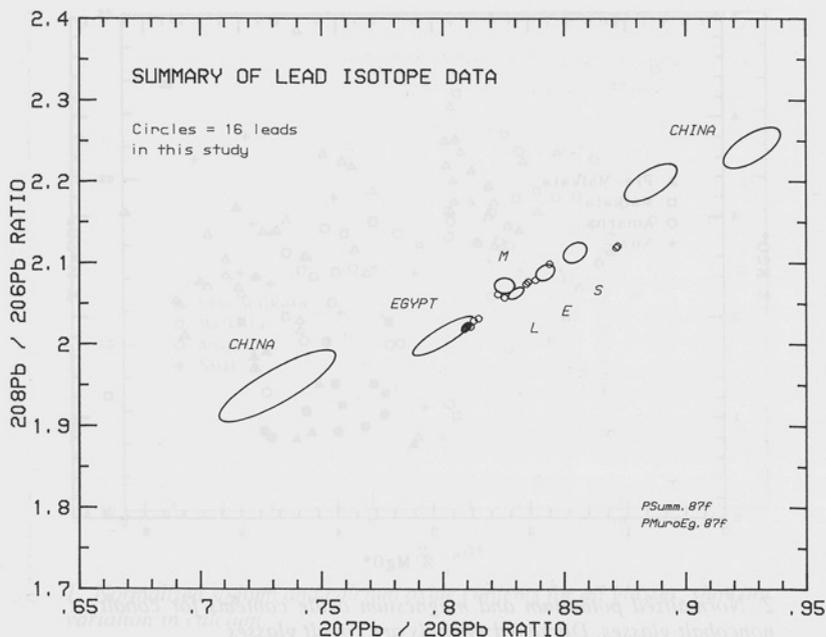


2. Normalized potassium and magnesium oxide contents for cobalt vs noncobalt glasses. Darkened symbols are cobalt glasses.

understood the triangles on it as a garland of lotus petals, but now wonders whether it isn't a decorative pattern from Palestinian pottery, as on Late Bronze I pottery examples that follow long traditions.

In conjunction with these archaeological studies, we did as much analytical work as conditions allowed. One of us, Robert Brill at The Corning Museum, added a good deal to the compositional analysis undertaken by Mark Wypyski at The Metropolitan Museum by providing comparative data for, and interpretation of, sodium/calcium and potassium/magnesium ratios of pre-Malkata glasses with data from Malkata and Amarna in Egypt, and Nuzi in northern Mesopotamia (figs. 1-2) (fig. 54). A graph (table 3, p. 41) shows the wider variability of calcium in pre-Malkata glasses than in Malkata/Amarna glasses: not unreasonable, given the much greater time period and possibility of multiple factory sites for the earlier glasses. And in a study of elemental composition in the 39 pre-Malkata glasses, we were able to see the Wadi Qirud glasses relate to other Tuthmosis III glasses; the Amenhotep II glasses cluster in a tight group; and the Tuthmosis IV samples align themselves nearby.

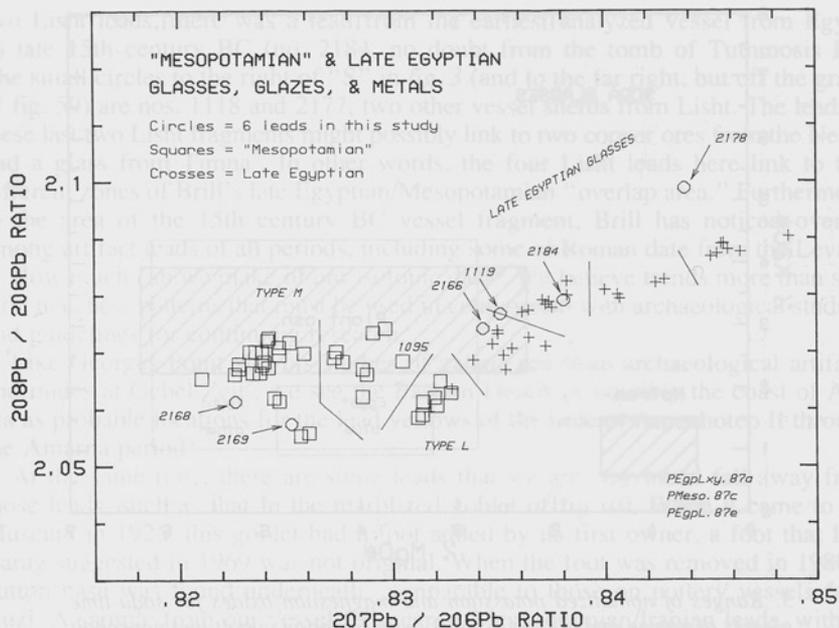
In a comparison of the mean values of calcium, potassium, magnesium and iron, we also found that the non-cobalt pre-Malkata glasses had their closest relation with non-cobalt glasses from Nuzi. More intriguing, a graph with the pre-Malkata, Malkata, and Amarna data — superimposed on Brill's natron and plant-ash values — showed overlapping of the Egyptian glasses with plant-ash glasses gathered from



3. Summary of lead-isotope data for some 800 ancient artifacts, including those of this study. Objects are of a wide variety of materials, periods, and provenances. Some ores are also included. The ellipse marked "Egypt" contains 50 Egyptian samples dating from Dynasty 18 or earlier. The ellipse marked "M" contains about 40 artifacts, mostly of Mesopotamian and Iranian origin. L, E, and S are groups established previously, but now used mainly by R.H. Brill as reference markers. "L" denotes Laurion (or Laurion-like) leads in both ores and provenanced artifacts; "E" English and some European leads; "S" Spanish and certain other leads. Late Egyptian glasses fall between L and E. All data for composing this graph are from the National Institute of Science and Technology (formerly the National Bureau of Standards). Superimposed on the graph as circles are 16 leads (yielding 17 points) in this study = Lilyquist & Brill 1993, 59-76. Samples 1118 and 2177 from Lisht are the two points to the right of the ellipse labeled "S".

Mesopotamia (figs. 2 and 5). To date, we believe there is insufficient experimental evidence with a direct bearing on Egyptian glasses to go further with this train of thought — experimental work that could establish a basic recipe or recipes. We are interested in such work, and it is the type of project that could be done in conjunction with the new workshop material from Amarna or Qantir. We feel that an important tool to be applied in this connection is oxygen isotope analysis, since it can operate independently of chemistry<sup>4</sup>.

<sup>4</sup> Brill 1970 and 1986.

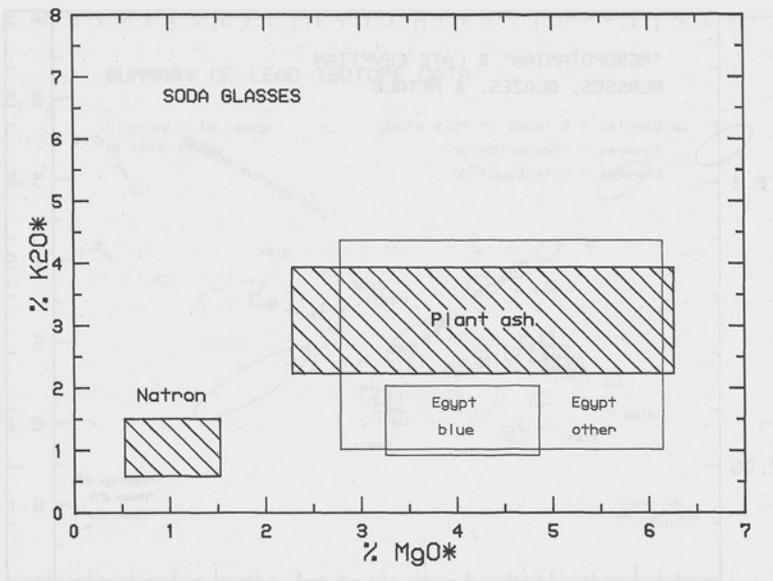


4. Expanded portion of fig. 3 showing Type M "Mesopotamian" and "late Egyptian" leads. Mesopotamian and Iranian samples are denoted by squares; late Egyptian glasses (chiefly Ptolemaic and Roman but also Dynasties 23 or 26) by crosses. Samples 1119 (Lisht) and 2184 (Tuthmosis III) resemble leads in the late Egyptian glasses. Samples 2168 (foreign wives goblet) and 2169 (tin bead) are on the borderline of Group M, and are clearly more like "Mesopotamian" artifacts than they are like their contemporaneous Egyptian counterparts which lie off this graph to the left. No. 1095 is from a marbled vessel sherd from Nuzi; 2166 from a marbled vessel sherd from Susa. Lines separate groups. Sizes of individual points are about  $\pm 0.05\%$  of nominal values.

Another analytical find among the Egyptian glasses is illustrated in fig. 2: that the "blues," i.e., cobalt-colored glasses, differed from non-cobalt glasses, and must have been made with a different recipe. The cobalt glasses of all three Egyptian groups fell together, although they did not always have the composition Alex Kaczyjmark had suggested for a Dakhleh Oasis source of cobalt<sup>5</sup>.

One of the frustrating aspects of the study was the small number of samples available for use. As far as we know, no samples have been removed from glasses in the Cairo Museum; thus we used dated or datable items in New York that were

<sup>5</sup> McGovern, Fleming, and Swann reported low manganese at Beth Shan, and mixed results from the Amarna specimens they analyzed (McGovern et al. 1993, 17); Segnit (1987, 99) queried whether ancient technology could have extracted cobalt from magnesium sulphates.



5. Ranges of normalized potassium and magnesium oxides for soda-lime glasses of natron and plant-ash types, with Egyptian cobalt and noncobalt glasses superimposed.

large enough to yield unweathered samples. Hopefully, other scholars will add analyses to our small corpus, although there will then be questions arising from different instrumentation and methodology.

As for isotope studies in our project, we were both fortunate and limited. We had the unpublished data of The Corning Museum of Glass at hand, but very few metallic ores for comparison. Many of you are aware of the data Brill has gathered, referencing lead ores and artefacts found in China, Egypt, Mesopotamia, Laurion, England and Europe, Spain, and again China — as shown in *fig. 3*.

Brill found that most of the pre-Malkata samples lie near his “Egyptian” field (see also *fig. 59*). At the same time, several fell near or in his M (Mesopotamian) field: no. 2168, a marblized goblet, and no. 2169, a tin bead (*fig. 4*)<sup>6</sup>. In this field there is a marblized sherd from 15th century Nuzi (no. 1095), and an undated marblized sherd from Susa (no. 2166). Even further out on the graph is what Brill has mapped as “late Egyptian glasses” — *fig. 60* and between “L” and “E” on *fig. 3*. In this area he found a cane (no. 1119) and vessel (no. 2178) from Ramesside Lisht (approximately, 12th century BC); the cane was positioned near leads found at 1st millennium Susa, Persepolis, and Hasanlu. At the same time, between the

<sup>6</sup> With 0.6% lead, the source of tin is indicated. Related samples are from Tell el-Rimah, the Taurus mountains, and the Ulu Burun shipwreck.

two Lisht leads, there was a lead from the earliest analyzed vessel from Egypt, ca late 15th century BC (no. 2184, no doubt from the tomb of Tuthmosis III). The small circles to the right of "S" in *fig. 3* (and to the far right, but off the graph of *fig. 59*) are nos. 1118 and 2177, two other vessel sherds from Lisht. The leads in these last two Lisht fragments might possibly link to two copper ores from the Negev and a glass from Timna<sup>7</sup>. In other words, the four Lisht leads here link to two different zones of Brill's late Egyptian/Mesopotamian "overlap area." Furthermore, in the area of the 15th century BC vessel fragment, Brill has noticed overlap among artifact leads of all periods, including some of Roman date from the Levant.

How much can we make of our isotopic data? We believe trends more than specific matches; patterns that must be used in conjunction with archaeological studies; and guidelines for continuing research.

Like Georges Pouit and his studies of galena ore from archaeological artifacts and mines at Gebel Zeit<sup>8</sup>, we see the Eastern Desert or possibly the coast of Arabia as probable locations for the lead yellows of the time of Amenhotep II through the Amarna period<sup>9</sup>.

At the same time, there are some leads that we are convinced fall away from those leads, such as that in the marblized goblet of *fig. 10*. When it came to the Museum in 1926, this goblet had a foot added by its first owner, a foot that Dan Barag suggested in 1969 was not original. When the foot was removed in 1980, a button base was found underneath, comparable to those on pottery vessels from Nuzi. A sample from our vessel fell nearest Mesopotamian/Iranian leads, without actually matching several marblized sherds from Nuzi and Susa<sup>10</sup>.

This is where the gathering of various types of expertise was essential. Indeed, we had found glassy materials in Egypt that preceded or were contemporary with our marblized goblet (*fig. 9*). But clearly the sophistication of the pattern, the vessel itself, and other vitreous samples from Nuzi (*figs. 11-12*), Alalakh, and Megiddo indicate that western Asia was far ahead of Egypt in the manufacture of vitreous material at this time. The coloration, the marbling pattern, and the shape of our vessel from the Wadi Qirud combine with the evidence from composition and isotope ratios to indicate that our goblet was an import to Egypt. In fact, it seems likely that our vessel could have had an impact on the local industry in Egypt, in the sense of being the type of ware that inspired the marbled pattern of Egyptian-made glass vessels from the tomb of Amenhotep II in *fig. 19* (center and upper right). Two Assur glass vessels recently exhibited in the Metropolitan Museum from Middle Assyrian graves show how sophisticated approximately contemporary Near Eastern glass vessels could be<sup>11</sup>.

The discoveries highlighted in this paper came about through the collaboration of archaeology, art, chemistry, and isotope studies — a collaboration that is more

<sup>7</sup> Although there is overlapping with samples from Iran, Sardinia, and the Arabian Peninsula.

<sup>8</sup> Castel et al. 1989, 26, *fig. 11*, nos. 3-4.

<sup>9</sup> To our knowledge, an exact match between the glasses and an ore has yet to be found.

<sup>10</sup> Lisht lead is closest to that in the Sinai peninsula.

<sup>11</sup> Harper et al. 1995, nos. 69-70.

and more necessary as scholars build "banks of data". Interpretation, in fact, is becoming the central challenge.

For example, archaeologists refining the picture of ancient societies are now realizing that manufactured goods, raw materials, and people — and hence ideas — moved about more than might have been thought. The famous "Dolphin vase" from the late Middle Kingdom capitol at Lisht is now published as a southern Palestinian import of about 1700 BC on the basis of shape, context, and compositional analysis connected to a large data base<sup>12</sup>. The Hildesheim excavators at Ramesside Qantir in the Nile Delta say their metal and vitreous workshops have yielded "foreign tools" and "moulds for foreign objects"<sup>13</sup>. How then are we to interpret a glass vessel-fragment found in Vienna's excavations at the Hyksos-period Avaris, adjacent to the later Qantir?<sup>14</sup>

And how should we interpret something that "looks Egyptian" found outside Egypt? Two recent studies of Laurion lead illustrate that problem. Zofia Stos-Gale, Noel Gale, and Judy Houghton have just published 17 objects from Amarna with lead as an impurity. Without going into details of the data here, it can be noted that some items were isotopically indistinguishable from 200 objects found in the Aegean world that fell into the Laurion field of those scholars. The other Amarna items had a few matches outside Egypt but represented a larger group in Egypt. The scholars therefore suggested that the first Amarna group had been made with copper from Laurion and the second from copper mined within the Egyptian domain<sup>15</sup>.

In a second study involving Laurion lead, Robert Brill sampled two faience plaques found at Mycenae. These have Egyptian inscriptions on them but have Laurion or Laurion-like lead in their glaze (p. 61 n. 10). Was the lead in the glaze of these plaques imported from Greece to Egypt? Were the plaques made on the Greek Mainland in Egyptian style? Or do the Laurion mines overlap some Near Eastern mines? Our *fig. 4* shows six objects from Mesopotamian and Iranian sites that are isotopically indistinguishable from Laurion lead.

We cannot answer such questions at this point. However, let it be noted that after looking at vitreous and stone objects found in Lebanon, Israel, Jordan, Turkey, Cyprus, Greece, and Crete over the past few years, this Egyptologist has the impression that many "Egyptian" objects are actually "Egyptianizing," i.e., locally rather than Nile Valley made. The analytical work of Patrick McGovern, Stuart Fleming, and Charles Swann with faience and glass from Beth Shan at the period of the "Egyptian garrison" in Ramesside times presents this problem<sup>16</sup>. The two categories of vitreous materials presented had compositional differences, but their closest relationships were still with each other, not with items tested from Egypt.

<sup>12</sup> McGovern et al. 1994.

<sup>13</sup> Conference hosted by the Supreme Council of Antiquities, April 1995 (Cairo).

<sup>14</sup> Historisches Museum der Stadt Wien 1994, no. 323.

<sup>15</sup> Note that "it seems that copper mineralisations in the Eastern Desert are of little significance and there are no reports known to use of ancient copper slages in this region" (p. 127).

<sup>16</sup> Mc Govern et al 1993.

In conclusion, interpretation of the analytical data at the moment is complicated. Our impressions are that it is useful to separate data from theory, and that it is necessary to be cautious in labeling. Our hope is that further research and collaboration will lead to fuller enlightenment.

Brill 1970

Lead and oxygen isotopes in ancient objects / R.H. Brill; *Philosophical Transactions of the Royal Society of London A*. 269 (1970), 143-164.

Brill 1986

Scientific investigations of the Jalame glasse and related finds / R.H. Brill; *Excavations at Jalame, Site of a glass factory in late Roman Palestine* / G.D. Weinberg, ed.; St. Louis 1986, 257-294.

Pouit 1989

Géologie et minéralisations Pb-Zn du Gebel Zeit / Georges Pouit; *Gebel el-Zeit I, les mines de galène (Egypte, IIe millénaire av. J.-C.)* / Georges Castel et al.; Cairo 1989, 17-28.

Harper et al. 1995

*Assyrian origins: Discoveries at Ashur on the Tigris, Antiquities in the Vorderasiatisches Museum, Berlin* / Prudence O. Harper et al.; New York 1995

Historisches Museum der Stadt Wien 1994

*Pharaonen und Fremde, Dynastien im Dunkel* / *Historisches Museum der Stadt Wien*; 194. Sonderausstellung des Historischen Museums der Stadt Wien in Zusammenarbeit mit dem Ägyptologischen Institut der Universität Wien und dem Österreichischen Archäologischen Institut Kairo, Rathaus Wien, Volkshalle, 8 Sept. - 23 Oct. 1994; Vienna 1994.

Lilyquist 1993

Granulation and glass: Chronological and stylistic investigations at selected sites, ca. 2500-1400 B.C.E. / C. Lilyquist; *Bulletin of the American Schools of Oriental Research* 290-291 (1993), 29-94.

Lilyquist & Brill 1993

*Studies in early Egyptian glass* / C. Lilyquist and R.H. Brill with M.T. Wypyski; New York, Metropolitan Museum of Art 1993; reprint 1995.

McGovern et al. 1993

The late Bronze Egyptian garrison at Beth Shan: Glass and faience production in the late New Kingdom / P.E. McGovern et al.; *Bulletin of the American Schools of Oriental Research* 290-291 (1993), 1-28.

McGovern et al. 1994

The archaeological origin and significance of the dolphin vase as determined by neutron activation analysis / McGovern et al.; *Bulletin of the American Schools of Oriental Research* 296 (1994), 31-43.

Segnit 1987

Evaporite minerals from the Dakhleh Oasis / E.R. Segnit; *Ceramics from the Dakhleh Oasis*; Preliminary Studies of the Victoria College, Archaeology Research Unit, Occasional Paper No. 1; Burwood Victoria [New Zealand] 1987, 97-102.

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