A Laboratory Study of a Fragment of Painted Glass from Begram

By Robert H. Brill

Among the objects of glass in the collection of the National Museum of Afghanistan is an outstanding group of vessels and fragments excavated at Begram in the late 1930's by The French Archaeological Mission (1). These glasses date from between about 100 and 250 A.D., and are generally believed to have been made somewhere to the west, possibly in Alexandria. The group includes a few painted glass beakers (such as KM 58.1.3) and fragments of several similar objects, parallels of which are known from more westerly sources. (2)

Chemical analyses and other scientific investigations have now become an important part of the study of many types of archaeological objects, including glass. (3) From such studies it is often possible to learn something about the dates and places of manufacture of glass objects. The required experiments can sometimes be done nondestructively or in other instances with the sacrifice of samples no larger than a broken pencil point. Until now, however, only a few specimens of glass from Afghanistan have been analyzed. (4) Therefore, when the author visited the National Museum in 1968, he requested a loan of one of the small painted glass fragments to see what might be learned about it through laboratory studies. The loan was subsequently approved with the reasonable understanding that the fragment would not be damaged in any way. (5) This request was complied with and after the study was completed, the fragment was returned to Kabul completely intact. The fragment, which measures 3.0 cm. in greatest dimension, is shown in Figure 1. (Actually, it consists of six smaller bits assembled with an adhesive and with tape at sometime in the past.)
Figure 1. Fragment of painted glass from Begram analyzed and examined in this study. (Kabul Museum)

MICROSCOPIC EXAMINATION AND RADIOGRAPHY

Before beginning our chemical studies, a careful microscopic examination was made and the fragment was x-rayed as received. The microscopic examination established that the colored decorations were not simply painted on, but after having been applied, they were fired into place. Thus, the decorations can truly be regarded as enamels, and very early examples at that.

The radiograph (or x-ray) was taken by Mrs. Doris Martin of Corning Glass Works using regular medical equipment. The radiograph is reproduced in Figure 2. The base glass is only partially opaque to x-rays and shows a neutral gray appearance. This is typical of early glasses. Among the painted regions, only the yellow pigment is markedly opaque to x-rays. This indicated, even before the chemical analyses were carried out, that the yellow pigment was one of the ancient lead-containing pigments, Pb₂Sb₂O₇ or PbSnO₃, (6) which was in accordance with our expectations. Small bubbles or pinholes in the yellow region show up as dark spots in the radiographs. The other colors are not noticeably opaque to x-rays, from which we can conclude that none contain major proportions of lead, even the red pigment, which we had suspected might contain lead (7). It is also possible from this observation, to rule out the use of white-lead pigment for the white region or as a diluant for the pink region (8). There is a faint band showing on the radiograph
which does not seem to coincide with any of the painted regions of the decoration nor does it coincide with any of the specks of soil still on the fragment. The radiograph also clearly shows how the small pieces had been joined together. Since there was danger of the fragments becoming unglued, the old glue was dissolved, and the pieces were reattached with a more permanent adhesive before returning them to Kabul.

CHEMICAL ANALYSES

Two types of chemical analyses were carried out. One of these was an X-ray fluorescence analysis by Mr. Robert Giauque of the Lawrence Radiation Laboratory. The other was a laser probe analysis by Dr. William Young and Miss Florence Whitmore of the Boston Museum of Fine Arts. Analyses were made both of the glass itself and of the colored pigments in the decoration. For comparison, analyses were also carried out on a few similar specimens of painted glass in the collection of The Corning Museum of Glass. (See note 2). The results are tabulated in Table 1.

The base glass is of the soda-lime-silica variety (Na₂O : CaO : SiO₂), as are most Egyptian, Mesopotamian, Roman and Islamic glasses. Like those glasses, the Begram glass also has relatively low potassium (K₂O) and magnesium (MgO) contents. This type of composition is distinctly different from those of all the glasses so far analyzed, which are known to have been made in Central Asia. Although the later are also soda-lime-silica glasses, they have, in addition, considerably higher potassium and magnesium contents, (9) owing to the types of raw materials from which they were prepared. (10). Consequently, we can conclude definitely that this painted glass was not made in Afghanistan, which affirms what has been believed previously about the glass objects found at Begram. The glass contains an intentional addition of antimony (Sb₂O₅), which also places it in the category of ancient glasses decolorized by this means. This finding is consistent with an attribution to Alexandria, but glasses from other sources as well were decolorized with antimony up through the third century.

Constituents which are common to all of the regions of colored decoration are silica (SiO₂), lime (CaO), alumina (Al₂O₃), magnesia (MgO), and lead (PbO). These are assumed to be ingredients of the vitreous matrix supporting the pigments and, to some extent, the glass beneath the colored decorations. The principal colorants in each region are listed below, in some cases along with supporting elements which are believed to have been additives intended to aid in producing the colors. Iron and manganese might affect the color, but are believed not to be parts of the principal colorants other than in the brown region.

**Blue—Co,Cu** The cobalt and copper are “in solution”.
**Red—Cu** The copper is present as small crystallites of Cu₂O.
**White—Ca,Sb** The colorant is probably the white pigment Ca₂Sb₂O₇.
A laboratory Study of a......

Pink—Cu, Ca The colorant is the red pigment Cu₂O, diluted with a Sb, As white pigment, probably Ca₂Sb₂O₇. Arsenic may also be associated with the colorant in some way.

Yellow—Pb, Sb The colorant is the yellow pigment lead antimonate, Pb₂Sb₂O₇.

Brown—Fe Chemical form not determined.

In addition, traces of gold (Au) were found in the pink and yellow zones, indicating that parts of the vessel might once have been gilded.

The analyses of the colorants are the same as those obtained for similarly colored regions in the three fragments of painted Roman glass in The Corning Museum of Glass. (See note 2.) In connection with the blue colorant, it might be noted that in a soda-lime-silica vitreous matrix such as was used for preparing this “enamel”, dissolved copper (Cu) produces a blue color. In a lead-containing matrix, such as is used for many pottery glasses, the dissolved copper produces a strong green color.

RECOMMENDATION FOR FURTHER STUDY

From the chemical analysis it can be seen that the yellow opaque region contains lead and antimony, undoubtedly in the form of the lead antimonate pigment Pb₂Sb₂O₇, which was widely used for glasses and glazes in ancient times. (11). This suggests that another extremely valuable experiment should be carried out, a lead isotope determination on lead in the pigment. Such information would be useful in determining exactly where the object might have been made. (12) We hope it will be possible to undertake such an experiment sometimes in the future.

FOOTNOTES—BRILL


2. A close parallel is the large fragmentary beaker in the Metropolitan Museum of Art, no 22. 2.36-37. The Daphne Vase and The Paris Plate in The Corning Museum of Glass (nos. 55.1.85 and 55.1.86) are related, but are “cold-painted”. Their pigments, which have been analyzed but not yet published, are red ochre for the red in both pieces, gypsum and white lead respectively for the white regions, and carbon black. There are also several fragments of early painted glasses having “fired-on” paints, or enamels, in The Corning Museum of Glass. (For example, nos. 59.1.83, 59.1.84 and 59.1.279). Two large blue glass flutes decorated with painted designs were recently excavated by Dr. Jean Leclant at Sedeigna in the Sudan. Ray W. Smith has
published information on a group of painted cups of the Roman Period in *Saalburg-Jahrbuch*, XIV, 1955, pp. 60-64.


5. We are very grateful to His Excellency Dr. Mohammad Anas, who was then Minister of Information and Culture, and to Mr. Ahmad Ali Motamedi, Director General of the Museum, for granting this loan, and to Professor and Mrs. Louis Dupree who aided us greatly.


8. The Paris Plate, which has “cold-painted” decoration, contains white lead. See note 2.

9. See reference cited in note 4. Glasses made in Central Asia usually contain about 4 to 7% CaO and about 3 to 6% MgO.

10. For information on raw materials see reference cited in note 7.


### Chemical Analyses of Glass and Painted Decorations

<table>
<thead>
<tr>
<th>Glass body</th>
<th>Blue region</th>
<th>Red region</th>
<th>White region</th>
<th>Pink region</th>
<th>Yellow region</th>
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<td>Fe₂O₃</td>
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<tr>
<td>SnO₂</td>
<td>Cu 0.1-1</td>
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<tr>
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* Sought, but not found in glass: Li, Rb, Co, V, Cr, Ni, Zn, Zr, Bi, P, As.
* * Incomplete analysis.

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