ones. The cobalt-colored beads tend to have relatively low sodium (7 to 10%).

There are also differences in calcium levels. The cobalt-colored beads have relatively high Ca (4-8%), whereas most copper-colored beads range between 1 and 5%. Once again, there are temporal differences within the group of copper-colored beads: the 16th-century beads are very low in calcium (most between 1 and 2%), while 17th-century ones display slightly higher levels (2-5%).

One characteristic of the late 16th-century copper-colored beads is their tendency to be found in a disintegrated state, sometimes consisting of nothing but a blue or green powder with glass particles reduced to the size of sand grains. Analyses of such disintegrated beads from the Kleinberg, Molson, and Adams sites reveal that the glass has been largely stripped of its sodium content (under 4%).

It is perhaps significant that the 16th-century turquoise-glass beads in general have low Ca, particularly the disintegrated ones (0.5-1.5%). This suggests that these beads had an insufficient amount of calcium to prevent them from being chemically attacked. In contrast, the cobalt-colored beads, with their high Ca content, are not normally found in this disintegrated state.

Minor Elements

Chlorine ranges from about 0.5 to 2.1%, copper-colored beads displaying greater quantities than the cobalt ones. The chlorine content is closely correlated with Na levels, suggesting that the chlorine was added to the glass as an impurity in the soda ash.

Aluminum ranges from 0.3 to 1.2%, but there is no patterned variation with either time, space, or major colorant type.

The amount of arsenic is closely related to cobalt content. Since arsenic is present in many cobalt ores (e.g., cobaltite and skudderudite), the ratio of As to Co may ultimately prove useful in determining the cobalt source or sources used in coloring the dark blue beads.

Conclusions

The 16th- and 17th-century blue glass beads studied here have two basic chemically produced hues: turquoise blue (copper) and dark blue (cobalt), although variation exists depending on the particular amounts of these colorants as well as the presence of such color modifiers as manganese and tin. In the turquoise beads there are chemical differences through time, although it is presently unknown whether this represents a general change in manufacturing process or a shift in the source of supply. Spatial differences in the manganese content of the 17th-century copper-colored beads suggest the possibility of discriminating French and Dutch trade items, although more analysis is required to confirm this.

Acknowledgements

Much of the analysis was undertaken by A. Chafe for the "Ancient Materials" course (JAM20l2) at the University of Toronto: the substantial encouragement and guidance of Dr. Ursula Franklin is gratefully acknowledged. The analytical work was made possible by an infrastructure grant from the Natural Sciences and Engineering Council of Canada to the SLOWPOKE Reactor Facility at the University of Toronto. Beads used in the analysis were generously supplied by the Rochester Museum and Science Center (Charles Hayes III), the Huronia Museum (James Hunter), and the Ontario Ministry of Transportation and Communications (Paul Lennox).

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6. GLASSWARE OF THE 10TH-13TH CENTURIES ON SITE 1, GDANSK, by Aldona Chmielowska (1985, 7: 14-16)

(English summary of "Wyroby Szklarskie z X-XIII Wieku na Stanowisku 1 w Gdansku," by Aldona Chmielowska, 1960, Prace Komisji Archeologicznej, Nr. 3, *Gdansk Wczesnosredniowieczny*, Tom 3, pp. 105-158, Plates 1-3. Gdansk.)

The archaeological investigation of site 1 in Gdansk has resulted in the recovery of a rich and varied collection

of cultural material which offers an excellent opportunity for the examination of social and economic relations in early feudal Poland. The material discussed comes from 17 habitation layers of a fortified urban settlement which existed from A.D. 980 to A.D. 1308, when it was burnt down by the Knights of the Order of St. Mary.

Of the glass objects, beads form the most numerous group, whereas rings and ring-settings rank second and fragments of glass vessels third. According to their external features, beads were divided into three groups: transparent beads, opaque beads, and glazed beads. The transparent beads were subdivided according to shape, whereas the basis for the classification of opaque beads was provided by their shape, ornament, and general character.

In contrast to Kruszwica and Wolin, Gdansk did not yield direct evidence for the local production of glass ornaments. Therefore their origin had to be established on the basis of technological analysis. In the early Middle Ages three principal types of glass were produced: soda glass in the east (identical glass was produced in the Rhenish land until the close of the 9th century), potash glass made particularly in the West since the 10th century, whereas in Old Russia glass composed mainly of lead and potash predominated.

Fourteen objects from Gdansk were subjected to chemical and spectroscopic analyses. The analysed relics consisted of transparent beads, opaque ornamented beads, rings, and fragments of glass vessels. Objects made of lead-potash glass predominated. This glass served principally for the production of transparent beads, rings, and opaque undecorated beads. On the other hand, analysis of the glass vessels revealed that one was made of potash-lime glass and another of soda-lime glass. A recovered glass lump was also of the soda-lime kind. The last mentioned objects may have been imported from foreign lands. The closest analogy for the lead-potash glass objects is furnished by Old Russian glassware. There is, however, an element which shows the peculiarity of Polish glass, namely tin. Neither Arabic nor Western European glass contains it. In Old Russia small quantities of tin occur in mosaic glass alone. Tin was probably used for the devitrification of glass. It was found in 7 of 11 examined beads and rings.

The examination of glass objects from Gdansk has revealed the following:

a) The predominant glass ornaments were chiefly made of lead-potash glass with an admixture of tin. Consequently it is possible that they were produced locally during the 320-year existence of the fortified urban settlement of Gdansk.

b) Glass objects differing from the former in chemical composition are probably of foreign origin.

c) Along with glass ornaments produced locally, the site yielded glass ornaments and vessels indicative of commercial contacts between Poland and other countries.

d) Of the glass ornaments, the most numerous are the transparent beads (81 specimens), next the opaque undecorated beads (48 specimens), then opaque decorated beads (33 specimens), while the glazed beads (20 specimens) are the least numerous.

The transparent beads of lead-potash glass may be of local origin. Probably also of local make are the opaque beads, irregular in shape and without ornamentation. The opaque beads decorated with coloured motifs seem to be the result of commercial relations between Poland and other countries.

e) Apart from foreign commerce, an internal trade in glass objects may have existed in early medieval Poland. For the present, however, we do not know which glass factories of Poland could have distributed their products on an extensive scale.

7. CZECH BEADS, by Vladislav Chvalina (1992, 21:5-8)

Jablonec Jewelry has contributed to the great tradition of Czech glass through its manufacture of glittering glass beads in numerous beautiful styles.

For almost two and a half centuries, the manufacturing center for Czech jewelry has been in the Jizera Mountains in Northern Bohemia, mainly in the vicinity of the picturesque town called Jablonec nad Nisou. The jewelry is, of course, closely related to the production of glass beads. Skilled glassmakers in the region used to make hundreds, perhaps thousands, of different kinds: various shapes, sizes, and colors of beads. The same type of bead production continues today.

The “seed” beads, most of all “rocailles” (a tiny, brightly colored round bead), and “two-cut” beads, have an interesting history and unforgettable charm. The exhibition called “Rocailles in the History of Nations,” held October-November, 1990, in St. Peterburg, Russia, revealed how important small glass beads were in the life of many nations. That is why we find Czech beads in the villages of native people in all corners of Africa, America, Canada, and the northern part of the former Soviet Union, as well as in the Far, Middle, and Near East. The traditional costumes of many European nationalities were richly decorated with seed-bead embroidery.