COBALT GLASS AS A LAPIS LAZULI IMITATION

By George Bosshart

A necklace of round beads offered as "blue quartz from India" was analyzed by gemological and additional advanced techniques. The violet-blue ornamental material, which resembled fine-quality lapis lazuli, turned out to be a nontransparent cobalt glass, unlike any glass observed before as a gem substitute. The characteristic color irregularities of lapis (white in blue) had been imitated by white crystallites of low-cristobalite included in the deep blue glass.

The gemological world is accustomed to seeing gemstones from new localities, as well as new or improved synthetic crystals. With this in mind, it is not surprising that novel gem imitations are also encountered. One recent example is "opalite," a convincing yet inexpensive plastic imitation of white opal manufactured in Japan. This article describes another gem substitute that recently appeared in the marketplace.

Hearing of an "intense blue quartz from India" was intriguing enough to arouse the author's suspicion when a necklace of spherical opaque violet-blue 8-mm beads was submitted to the SSEF laboratory for identification. Because blue quartz in nature is normally gray-blue as a result of the presence of TiO_2 (Deer et al., 1975, p. 207) or tourmaline fibers (Stalder, 1967), this particular identification could be immediately rejected. Although synthetic cobalt-colored quartz exists, thus far it has been produced only in a transparent form. The beads of the necklace we examined resembled more closely a fine lapis lazuli, with the characteristic color irregularities of lapis, yet they displayed a tinge of violet exceeding that of top-quality lapis and they contained no pyrite grains. Accordingly, a series of gemological and other tests were conducted to determine the precise nature of this unusual material.

RESULTS OF GEMOLOGICAL TESTING

The properties compiled in table 1 clearly indicate that the material is not lapis lazuli or any other natural material, but rather a man-made cobalt-colored substance, apparently a glass. While the refractive index of the tested material (1.508) does not differ markedly from that of lapis (approximately 1.50), its specific gravity of 2.453 is significantly lower than the average for lapis (approximately 2.80). The absorption spectrum (figure 1) differs from that of a blue-filter glass only by its slightly stronger iron peaks and by a shift in the ultraviolet absorption edge from approximately

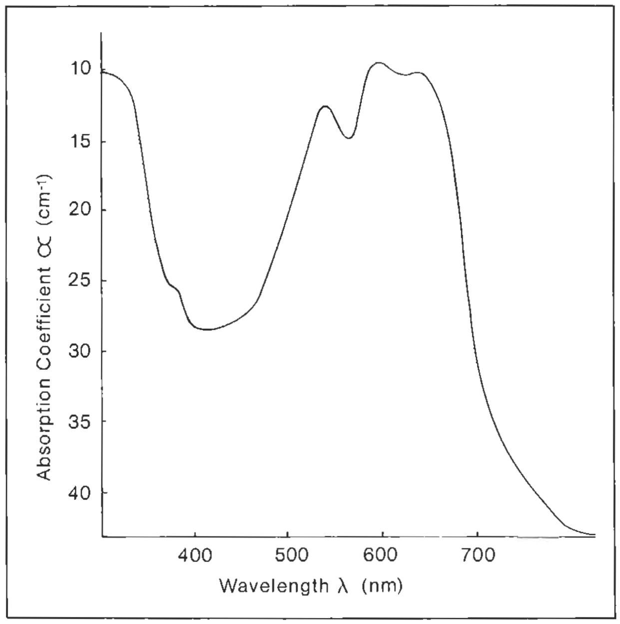

Figure 1. Absorption spectrum of a cobalt glass imitating lapis lazuli recorded through a chip of approximately 1.44 mm thickness in the range of 820 nm to 300 nm, at room temperature (Pye Unicam SP8-100 Spectrophotometer).

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TABLE 1. Properties of a cobalt glass imitating lapis lazuli.

Property	Description
Color	Violetish blue of strong saturation
DIN 6164 color indices[a]	15½ : 6 : 4 (hue, saturation, darkness)
Degree of transparency	Opaque to semitranslucent (in thin sections, translucent to transparent)
Absorption (recorded at room temperature)	Strong bands at 642, 592, 535 nm (cobalt); faint bands at 490, 438, 378 nm (iron)
U.V. fluorescence	Long-wave: extremely weak Short-wave: absent
Refractive index, n_D	1.508 on a section (spot readings slightly lower)
Optical character	Isotropic (in thin sections: anomalous extinction)
Luster	Vitreous (slightly silky sheen on inclusions)
Apparent porosity	Nonporous
Specific gravity (4°C)	2.453 (one specimen)
Surface	Smooth, spherically molded
Surface of fractures	Conchoidal to almost flat, with fine structure
Luster of fractures	Waxy to vitreous
Streak, scratch	Both white
Mohs hardness	Approximately 5½
External characteristics	Regular circular shrinkages around drillholes, few subspherical depressions (molding marks?), and several filled angular cavities on bead surfaces
Internal characteristics	White crystallites of micrometer size forming dendritic and large radiating to stellate patterns, in most cases surrounded by transparent blue areas and emanating from a grainy center
Reaction to heat	None to thermal test tip
Reaction to ferromagnetism	None
Reaction to diluted HCl	None
Chemical elements	Si; Ca, Ti, Mn, Fe, Co, Cu, Zn, As (as detected by energy-dispersive X-ray fluorescence)

[a]*West German color chart system on the basis of C.I.E. illuminants.*

290 nm to 320 nm (also the result of trace amounts of Fe). It must be stressed that the peak positions and intensities visually observed with the spectroscope partially deviate from the recorded spectrometer data provided in figure 1. With the spectroscope, the bands were seen to be centered at about 660 nm (strong), 585 nm (medium, narrow), and 530 nm (medium strong, very wide, asymmetric). Apart from the band at 490 nm (very weak), no other faint iron bands, recorded by the spectrometer, were detected with the spectroscope.

The photographs in figures 2 and 3, taken in reflected light, show bands and aggregates of white inclusions that are essentially of two types. One is a flat dendritic or fernlike array (similar to that in figure 9, "metajade," of Hobbs, 1982). The other consists of planes in radiating to stellate patterns similar to coral septa, with the planes perpendicular to the bead surface, indicating that the glass was annealed. In contrast to the macroscopic appearance of the material, the inclusion patterns seen under magnification are completely different from the aggregates of small blue, white, and frequently metallic yellow grains commonly seen in lapis lazuli. In figure 3, shallow depressions on the spherically molded glass can be recognized, and are in part filled with a white, grainy material that evidently had never melted. However, true bubbles or swirls were not detected, although the glass was observed with the microscope to be fairly transparent around the white inclusions. The inclusions themselves ranged in size from a few micrometers for the tiny white grains that form the two types of aggregates to approximately 3 mm for the longest septa and several millimeters for the ferns.

CHEMICAL AND X-RAY DIFFRACTION DATA

According to Bannister's diagram for conventional glasses (Webster, 1975, p. 386), a calcium or even a borosilicate glass could account for the refractive index and specific gravity determined, but no reference to this particular lapis-imitation glass was found in the gemological literature (Crowningshield, 1974; Farn, 1977; Schiffmann, 1976; Webster, 1975; and footnote below*; although

**A very old, if not the oldest, artificial lapis-like material dates back to pre-Christian times, when Egyptians sintered calcite, quartz, malachite, and azurite to create a brilliant blue substance that is now called "Egyptian blue." In ancient Egypt this material was used for scarabs, to ornament royal tombs, and, in powdered form, as a pigment and cosmetic. The chemical composition of "Egyptian blue" is close to, and its crystalline structure identical with, the mineral cuprorivaite,* $CaCu[Si_4O_{10}]$ *(G. Bayer, personal communication). The production of this material was made particularly successful through the application of lead oxide or alkali fluxes. If less Ca and Cu, but more alkalis, were used, a well-melted transparent-to-opaque glass (colored by Cu alone, or by Cu, Co, and Fe) would result (Bayer and Wiedemann, 1976).*

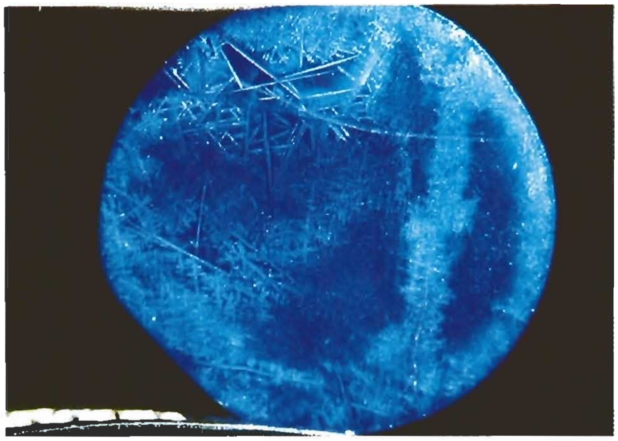

Figure 2. White bands and radiating septa of low-cristobalite in a devitrified, opaque cobalt-glass bead imitating lapis lazuli. Section through bead in reflected light; magnified 6× (Wild M8/MPS55).

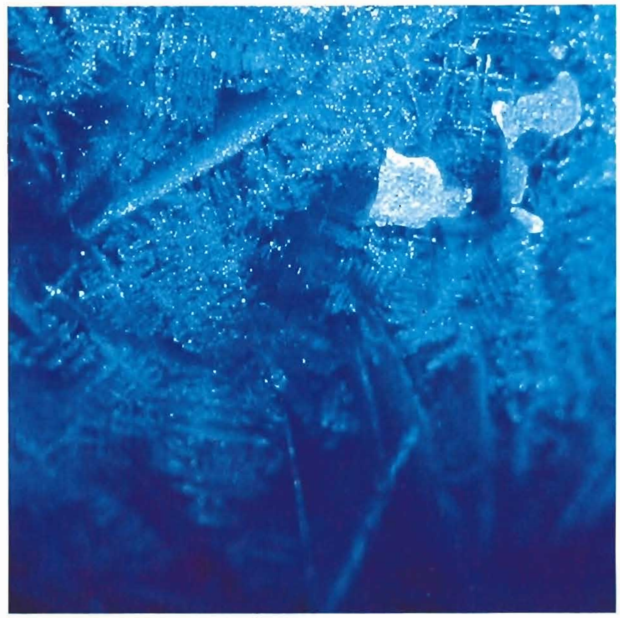

Figure 3. Dendritic and radiating patterns of white low-cristobalite exsolutions and essentially transparent blue areas in a cobalt-glass bead imitating lapis lazuli. Reflected light, magnified 13× (Wild M8/MPS55).

Nassau, (1980), reported a pyrite-lapis imitation made of another blue specialty glass that contains copper crystals, similar to a "goldstone"). Chemical data, nowadays readily available through nondestructive energy-dispersive X-ray fluorescence (XRF-EDS; Stern and Hänni, 1982), were certainly of interest in this case. Figure 4 exhibits no fewer than eight metallic element signals in addition to the strong silicon peak. When the AgL series produced by the silver tube radiation was successfully masked by a filter, the intensity of the Si peak was greatly reduced and an additional peak due to potassium was resolved, providing for the identification of at least nine metal oxides ad-

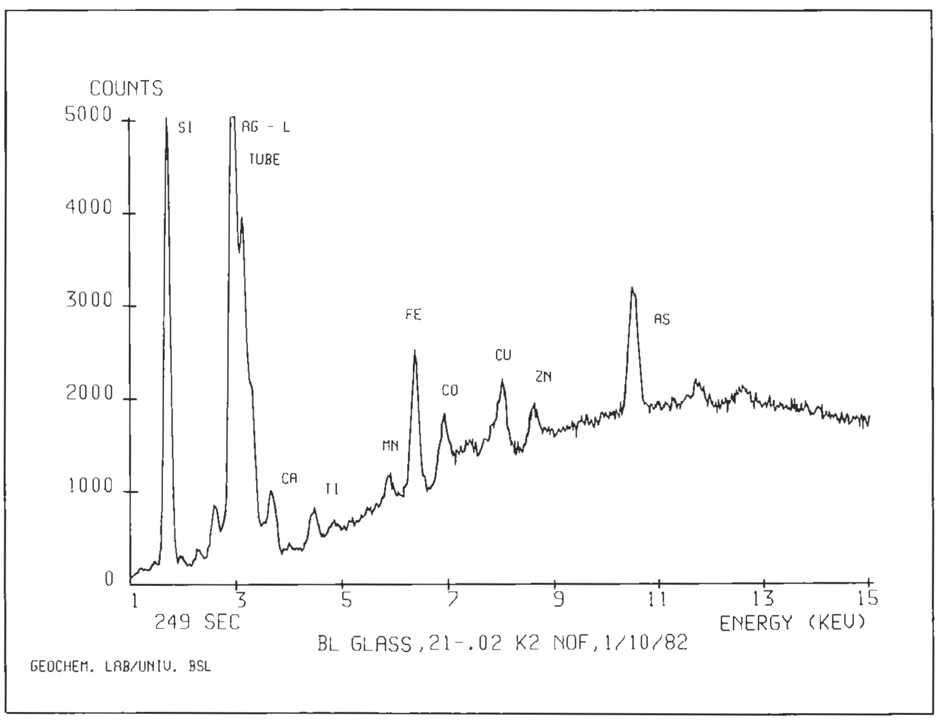

Figure 4. Unfiltered energy spectrum of a specialty cobalt glass imitating lapis lazuli; counting time 249 seconds (Tracor Northern 1710 X-ray Fluorescence Spectrometer).

mixed to the SiO_2 glass. Although boron cannot be detected by XRF-EDS analysis, the fact that the beads examined had a Mohs hardness of less than 6 (which is low for a borosilicate glass) would suggest that boron is not present in this material in significant amounts.

X-ray diffraction (XRD) provided the net identification of *alpha-cristobalite.* The X-ray film showed 12 sharp lines in appropriate identifying positions and relative intensities (JCPDS Powder Diffraction Data, 1974). The four strongest lines (with their estimated intensities indicated in parentheses) were at 4.05 Å (100), 3.14 Å (10), 2.84 Å (10), and 2.48 Å (20). Cristobalite is the only crystalline phase found in the glass. The mineralogical literature (Deer et al., 1975, etc.) describes natural alpha-cristobalite as the metastable low-temperature polymorph of SiO_2, with a tetragonal (pseudocubic) structure, a specific gravity of 2.32–2.36, and refractive indices of 1.484 (e) and 1.489 (o). Low-cristobalite is known to exsolve from certain glass types through a devitrification process. The degree of order in the low-cristobalite lattice depends on its thermal genesis.

CONCLUSION

The cobalt glass described in this article is the best glass imitation of lapis lazuli that this author has seen to date (see also Webster, 1975, p. 221). Although lapis lazuli was immediately eliminated as a possible identification, the results of the investigation were unexpected because:

- Glasses are not generally associated with opaque solids.
- The macroscopic appearance of the glass was confusing.
- No bubbles or swirls could be detected in the material studied.

The most diagnostic gemological property (considered along with the refractive index and specific gravity appropriate to a glass) is represented by cristobalite exsolution patterns seen under slight magnification. In this instance, the identification was secured beyond any doubt by the advanced techniques of spectrophotometry, XRF-EDS, and X-ray diffraction.

REFERENCES

Bayer G., Wiedemann H.G. (1976) Ägyptisch Blau, ein synthetisches Farbpigment des Altertums, wissenschaftlich betrachtet. *Sandoz Bulletin,* No. 40, pp. 20–39.

Biesalski E. (1957) *Pflanzenfarben-Atlas.* Musterschmidt-Verlag, Göttingen.

Crowningshield R. (1974) Imitation lapis lazuli: developments and highlights at GIA's lab in New York. *Gems & Gemology,* Vol. 14, No. 11, pp. 327–330.

Deer W.A., Howie R.A., Zussman M.A. (1975) *Rock-forming Minerals,* Vol. 4, Longman, London.

Farn A.E. (1977) Notes from the laboratory. *Journal of Gemmology,* Vol. 15, No. 7, pp. 358–372.

Hobbs J.M. (1982) The jade enigma. *Gems & Gemology,* Vol. 18, No. 1, pp. 3–19.

Joint Committee on Powder Diffraction Standards (1974) *Selected Powder Diffraction Data of Minerals,* No. 11-695. JCPDS, Swarthmore, PA.

Schiffmann C.A. (1976) Comparative gemmological study of lapis lazuli and of its new substitute. *Journal of Gemmology,* Vol. 15, No. 4, pp. 172–179.

Stalder H.A. (1967) Blauquarz vom Taminser Calanda. *Urner Mineralien-Freunde,* No. 5, pp. 1–16.

Stern W.B., Hänni H.A. (1982) Energy-dispersive X-ray spectrometry: a non-destructive tool in gemmology. *Journal of Gemmology,* Vol. 18, No. 4, pp. 285–296.

Webster R. (1975) *Gems.* Butterworths, London.