NOTES
· AND ·
NEW TECHNIQUES

IRRADIATED TOPAZ AND RADIOACTIVITY

By Robert Crowningshield

***A** parcel of 100 stones of deep blue irradiated topaz, imported from Brazil, was found to be radioactive at a level somewhat higher than typical background activity. Analysis indicates that the material had been treated by neutrons in a nuclear reactor. Most irradiated topaz in the trade is* not *radioactive. Nevertheless, routine testing for radioactivity in topaz, beryl, green diamonds, red tourmaline, and possibly all gemstones may be advisable for the protection of the jeweler.*

Large quantities of colorless topaz are currently being treated by gamma irradiation to turn them blue, a process that does not produce radioactivity in the stone (Nassau, 1980). The resulting color is a medium deep blue that is significantly darker than that of most natural blue topaz. A considerably darker color does result in rare instances (M. Welt, personal communication, 1981); this blue color is produced by a treatment (nature unknown) that is purportedly used on colorless topaz that will not turn blue with gamma rays (M. Welt, personal communication, 1981).

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Dr. M. Welt of Radiation Technology, Rockaway Township, NJ, was shown a parcel of about 100 unusually deep blue topaz gemstones that had recently been imported from Brazil. Upon testing, he found them to be radioactive. Two of these stones were further examined by the author and Dr. K. Nassau of Bernardsville, NJ, and are described below. Subsequently, Dr. Welt tested lighter blue topaz that also proved to be radioactive. Representative samples of light and dark irradiated stones and a larger, even lighter natural blue topaz are shown in figure 1.

EXAMINATION

The two stones, 8 cts. and 10 cts. in size, were exceptionally dark, fine-quality blue topaz. Gemological testing revealed a typical natural topaz: with two-phase inclusions typical of topaz, refractive index of 1.61–1.62, birefringence about 0.009, biaxial—doubly refractive, specific gravity of 3.57, no features observed in the spectroscope, and greenish fluorescence (long-wave, very faint; short-wave, barely detectable).

The 10-ct. stone showed about 0.2 milliroentgens per hour (mr/hr)* when tested in contact with a Geiger counter survey meter, while the parcel of about 100 stones shown to Dr. Welt

**The Roentgen, rad, rem, and rep are units used for radiation dose and differ only slightly in value. Microcuries (μc) are units that measure the quantity of radioactive material.*

Figure 1. Three representative samples of blue topaz. The two smaller stones on the left have both been irradiated to enhance color. The larger, lighter blue stone on the right has not been treated. Photograph by Tino Hammid.

measured at 12 mr/hr. Gamma-ray spectroscopic examination (K. Nassau, personal observation, 1981) showed the presence of the following amounts of radioactive elements:

scandium-46:	0.1 μcuries (half-life 84 days)
tantalum-182:	0.002 μcuries (115 days)
manganese-54:	0.002 μcuries (303 days)
iron-59:	0.001 μcuries (45 days)

These radioactive elements were probably produced from neutron exposure in a nuclear reactor by neutron reactions with scandium, tantalum, iron, and cobalt, respectively. It should be noted that the radioactivity from the major emitter, scandium-46, is quite penetrating, consisting of gamma rays with the relatively high energy of 889,000 and 1,120,000 electron volts.

DISCUSSION

A number of important points arise from these findings.

First, the nature of the radioactivity indicates that the stones were exposed to neutrons in a nuclear reactor. The importer stated that he had obtained several hundred of these stones some months previously in Brazil. Given the half-lives of the radioactive elements involved, it is obvious that the stones had been even more radioactive then; the dealer may have received an undesirable dose of radioactivity himself while carrying them about for some weeks. It is also evident that the stones were imported without the required radioactive materials import license (issued by the Nuclear Regulatory Agency).

Second, a spokesperson for the Nuclear Regulatory Agency stated that, for relatively low levels of activity such as might be associated with a single stone, there are no appropriate standards. This person added, however, the personal observation that the 0.2 mr/hr intensity of the 10-ct. stone definitely would be "not desirable" for extended personal wear.

Third, a survey conducted by Dr. M. Welt, Dr. K. Nassau, Mr. S. Church (of Church & Company, Bloomfield, NJ), and others of a wide variety of blue topaz, including several lots of the dark blue material, indicates that none of these others contained detectable radioactivity above the usual background reading of 0.02–0.05 mr/hr. Accordingly, it is not at present possible to determine the extent of the problem.

Fourth, radioactivity has been reported in a number of other gemstones, such as some of the Maxixe-type blue beryls (Nassau, 1973) and the occasional old radium-exposed green diamonds (Liddicoat, 1981). Testing in the Gem Trade Laboratory has shown that some of the latter are extremely high in radiation emission, darkening photographic film in just a few minutes. In addition, people are experimenting with irradiation on a wide variety of gem materials, for example,

to turn pale tourmaline dark red (Nassau, 1974). Tests show that some of these materials may also be radioactive. It should be noted that even if the color fades or is removed by heat treatment, the radioactivity still remains.

The specific type and intensity of the radioactivity will depend on impurities present in the gemstone as well as on the time of exposure in the nuclear reactor. All radioactive material slowly loses its activity, the time being dependent on the half-lives of the active elements involved.

Fifth, for the protection of his staff and himself personally, as well as for liability protection with respect to his customers, the jeweler (particularly one who handles large parcels of any particular type of gemstone) may wish to obtain a Geiger counter survey meter and check all parcels of stones. A similar test should probably be performed routinely on all stones examined in testing laboratories.

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NONFADING MAXIXE-TYPE BERYL?

By K. Nassau and B. E. Prescott

It is sometimes stated that there exists some Maxixe-type deep blue beryl (occasionally misnamed "aquamarine") that does not fade. All specimens ever reported in the literature did fade, typically to almost colorless in one to two weeks in bright sunlight or over a somewhat longer period under less intense illumination. A "nonfading" specimen recently examined proved to be typical fading Maxixe-type beryl. A possible reason why such a stone might give the impression that it is nonfading is discussed. With the exception of some brown topaz and some kunzite, no significant gemstone material fades on the same time scale as does Maxixe-type beryl.

Several years ago there appeared on the gemology scene a deep blue beryl that had unusual properties. Specifically, the material was at first designated aquamarine, but the dichroism of the stone differed from that of aquamarine. It was soon shown that the color faded upon exposure of the material to heat or to light. A detailed study (Nassau and Wood, 1973a and 1973b; Nassau et al., 1976) demonstrated that an irradiation-induced color center produced the color and that this material was closely related to, but not identical with, the naturally occurring deep blue beryl found in 1917 in the Maxixe mine in the Piaui area of northeastern Minas Gerais, Brazil, which also faded. The new material was designated "Maxixe-type beryl" to distinguish it from the original, natural "Maxixe beryl." Although the stones appear to fade at the same rate, the color centers in these two materials have been shown to be slightly different (Anderson, 1979).

Statements are occasionally made that specific specimens of Maxixe-type beryl do not fade. All such material studied in detail and reported in the literature has been found to fade (e.g., Nassau and Wood, 1973a and 1973b; Crowningshield, 1973; Schmetzer et al., 1974; Nassau et al., 1976; and Anderson, 1979). One such purportedly nonfading specimen recently became available to the authors; it was examined to establish if it did fade

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