
MILDLY RADIOACTIVE RHINESTONES AND SYNTHETIC SPINEL-AND-GLASS TRIPLETS

By Kurt Nassau and Edward A. Lewand

Low levels of radioactivity were found in some greenish yellow to yellow-green (peridot-like) synthetic spinel-and-glass triplets, mirror-backed glass rhinestone chatons, and fully fashioned glass rhinestones. Uranium was detected in the radioactive stones. Although individual stones in jewelry carry virtually no risk, it is recommended that parcels of such stones not be carried on one's person for prolonged periods.

Knowing that a broad variety of gemstones are candidates for irradiation treatment, many gem dealers routinely check all stones with a Geiger counter for radioactivity. This can often lead to surprising results, as was the case a few months ago, when a parcel of stones that should not have registered on the Geiger counter did just that. The dealer brought the stones to the authors' attention and, as a result, we have located three types of commercially available gem materials that show low, but not negligible, radioactivity.

Comprising the first type are triplets that consist of two layers of colorless synthetic spinel fused together with a thin layer of colored glass. Webster and Anderson (1983, p. 463) refer to these as *soudé sur spinelles*. According to trade sources, such spinel triplets are currently manufactured in Europe in a wide range of colors for use in birthstone jewelry, class rings, and the like. Only greenish yellow to yellow-green peridot-like material showed radioactivity, although not all material of this color did. Comprising the second type are peridot-colored rhinestones that consist of a crown with a flat, silvered (mirror) back. Known as *chatons*, these also are currently made in Europe and are usually sewn or glued onto clothing. Third, we found radioactivity in some fully faceted glass rhinestones, again of the same yellow-green color.

The use of lead oxide in glass to give it high dispersion, so-called flint glass, is well known (Webster, 1983, p. 437), as is the use of uranium compounds to produce a yellow-to-green color (Nassau, 1983; Webster 1983, p. 441). In fact, Webster (1952) reported examining a yellow doub-

let that consisted of a crown of rock crystal with a glass base containing uranium; he also noted the strong yellow-green fluorescence and "discrete (banded or fluted)" fluorescence spectrum that is characteristic of uranium. Unfortunately, the piece was not tested for radioactivity, as this was not considered a significant issue at that time.

To confirm the source and determine the levels of radioactivity in these three types of gem simulants, we examined several samples of each for both key gemological and chemical properties and for radiation activity (figures 1 and 2).

MATERIALS AND METHODS

We obtained a wide variety of synthetic spinel-and-glass triplets and glass rhinestones from several Manhattan stone dealers, from a mail-order finding catalog, and from the authors' collections. We ultimately focused on greenish yellow and yellow-green peridot-like material since our initial survey of dozens of stones of all available colors showed radioactivity only in these two hues. Some of the mirror-backed rhinestones tested also had an iridescent interference coating on the crown.

All 17 of the radioactive, as well as a selection of some of the nonradioactive, samples tested are described in table 1. Included as well are two pieces of rough: SC₂, a slab of triplet material of dimensions suitable for faceting small stones; and NA₅, one of several pieces of unfaceted uranium glass obtained a few years ago at the Tucson Gem and Mineral Show.

Conventional gemological testing was used to

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Figure 1. Some of the radioactive stones tested include, from left to right: back — LE_5 (a rhinestone), GR_1 and LE_2 (synthetic spinel-glass triplets); front — GO_1 and GR_2 (synthetic spinel-glass triplets), SW_2 (a chaton). Photo by Robert Weldon.

determine the optical constants and fluorescence for all of the radioactive samples and some of the nonradioactive specimens as well. The color descriptions are also given in ISSC-NBS Centroid color numbers (Kelly and Judd, 1976). Qualitative chemical analysis for five representative specimens (in the case of the triplets, for the glass exposed at the girdle) was performed on an X-ray fluorescence unit using a chrome target and a solid-state energy-dispersive detector with a PGT System 4 analyzer. Note that under these conditions one cannot detect chromium, vanadium, or elements below aluminum in the periodic table.

A Solar Electronics Radiation Alert Monitor 4 Geiger counter (thin-window type) was used to screen the stones for radioactivity. With a stone placed against the probe area, we averaged several one-minute counts for each specimen; the smallest stones were measured three at a time. The results are given in table 1 as radiation levels in terms of multiples of background, which is 12 counts per minute for this instrument in the test location used. We considered any reading lower than 1.5 times background to indicate absence of radioactivity by this test. More detailed radioactivity and elemental measurements were performed on three of the stones with a gamma-ray spectrometer, using a lithium-drifted germanium detector with a Canberra Series 80 multi-channel analyzer and two-hour counting periods.

RESULTS AND DISCUSSION

Gemological Data. All of the triplets in table 1 showed a refractive index of 1.729 to 1.730, which is consistent with synthetic spinel; some stones also showed a weaker indication of 1.69, derived from the glass. These results, as well as the anomalous double refraction typical of synthetic



Figure 2. Some of the nonradioactive stones tested include, from left to right: back — GO_3 and LE_1 (synthetic spinel-glass triplets), LE_3 (a rhinestone); front — SW_1 and NA_1 (chatons), NA_4 (a rhinestone). Photo by Robert Weldon.

spinel, are consistent with those reported by Kane (1986) for synthetic spinel-and-glass triplets. The glass layers ranged from 0.3 to 0.5 mm thick, contained gas bubbles, and were reasonably well centered at the girdle. The rhinestones in table 1 showed an R.I. of 1.57 to 1.58, with strain visible in the polariscope, gas bubbles and flow lines, and conchoidal fractures; all of these results are consistent with lead-containing glass.

All of the radioactive triplets showed medium to strong greenish yellow fluorescence to short-wave radiation and were inert to long wave. The non-radioactive glass chaton SW_1 had a similar fluorescence reaction, but radioactive SW_2 fluoresced a greenish yellow that was very weak to short-wave

TABLE 1. Glasses and synthetic spinel-and-glass triplets surveyed for radioactivity.

Sample no.	Color ^a	Color no. ^b	Size (mm)	Shape	Weight (ct)	Radio-activity ^c
Synthetic Spinel-and-Glass Triplets						
LE ₁	Yellow-green	115	12 × 10	Oval	5.39	—
GO ₃	"Emerald" green	139	9 × 7	Oval	2.02	—
RI ₁	Yellow-green	117	8 × 6	Oval	1.53	—
GR ₃	Yellow-green	117	8 × 6	Emerald	1.67	—
LE ₂	Greenish yellow	98	12 × 10	Pear	4.93	1.5
GR ₁	Greenish yellow	101	9 × 7	Oval	2.01	1.5
GR ₂	Yellow-green	116	9 × 7	Oval	2.00	1.5
GO ₁	Yellow-green	115	10 × 8	Oval	2.70	2
GO ₂	Greenish yellow	97	10 × 8	Oval	2.90	2
GO ₄	Greenish yellow	101	9 × 7	Oval	2.05	2
GO ₆ ^d	Yellow-green	116	3.5	Round	0.54	2
SC ₁ ^d	Yellow-green	115	5 × 3	Pear	0.81	4
SC ₂	Yellow-green	120	24 × 3	Slab	21.32	1.5, 4
Glass, Faceted and Rough						
LE ₃	Yellow-green	115	11 × 6	Pear	1.52	—
NA ₁	Colorless B	263	9	Chaton	1.97	—
NA ₃	Green BC	—	7	Round	1.43	—
NA ₄	Blue BC	—	7	Round	1.37	—
SW ₁	Greenish yellow B	104	9	Chaton	1.97	—
SW ₂	Yellow-green B	117	9	Chaton	2.17	4
LE ₄	Greenish yellow	104	10 × 8	Oval	2.07	4.5
LE ₅	Greenish yellow	101	12 × 10	Oval	3.83	5
NA ₅	Greenish yellow	97	26	Rough	40.20	13

^aB indicates a mirror back; C, an iridescent surface coating.

^bColor number from the ISSC-NBS Centroid Color Chart (Kelly and Judd, 1976).

^cActivity as number of times background; — indicates less than 1.5 times background; background was 12 counts per minute; the activity of 13 for NA₅ corresponds to a reading of 0.14 mR/hr.

^dConsists of three stones; weight and radioactivity level are the totals for all three.

U.V. but strong to long wave. Moreover, the triplet fluorescence observed here differs from that reported on similar material by Kane (1986). Accordingly, fluorescence cannot be considered diagnostic for radioactivity.

Elemental Composition. X-ray fluorescence confirmed that the synthetic spinels did not contain any significant amounts of metallic elements other than the expected Mg and Al (again, note that Cr, V, and elements lighter than Al could not be detected). Partial analyses of the glass for representative yellow-green and greenish yellow samples, both with and without radioactivity, are shown in table 2. All of the radioactive samples tested by elemental analyses or gamma-ray spectroscopy were found to contain uranium, which was clearly the coloring agent.

Radioactivity. Table 1 shows a range of radioactivity up to five times background in the faceted material and up to 13 times background in a piece of rough uranium glass. Different counts were

TABLE 2. Elemental analyses (as determined by X-ray fluorescence) of the glass in some of the stones in table 1.

Sample no.	Color and type	Radio-activity ^a	Elements detected ^b	
			High to medium	Low
LE ₂	Greenish yellow triplet	1.5	Pb, Si, K, Zn	U, Cu
SW ₂	Yellow-green glass chaton	4	Pb, K, Zn	U, Cu
LE ₁	Yellow-green triplet	—	Pb, Si, Ca, K	Fe, Cu
LE ₃	Yellow-green glass rhinestone	—	Pb, Si, K, Bi	Cu
SW ₁	Greenish yellow glass chaton	—	Pb, Si, K, Ti	—

^aTimes background, as in table 1.

^bElements not detectable under the analysis conditions used, but that could be present, include B, Li, Na, Cr, and V.

observed on the two sides of the triplet slab, since there is less absorption of the gamma rays from the uranium in the glass on the thinner synthetic spinel side intended to be the crown of the triplet.

Gamma-ray spectroscopy of three samples showed that the observed radioactivity was derived from natural (nondepleted) uranium and its daughter products. The measured radioactivity in nanocuries per gram (nCi/gm) is given in table 3. Although acceptable limits for radioactivity established in the U.S.A. vary considerably depending on a number of factors, 0.4 nCi/gm (NRC) and 2 nCi/gm (DOT) have been reported for certain gem applications by Ashbaugh (1988). Some of the stones are clearly above the lower of these acceptability limits.

CONCLUSIONS

Three types of greenish yellow to yellow-green (peridot-like) materials have been found to be radioactive: some synthetic spinel-glass triplets (in which the glass layer contains uranium as the colorant), some uranium-glass rhinestones in the form of silver-backed chatons, and some fully fashioned uranium-glass rhinestones. Although the radioactivity in some of these stones exceeds

TABLE 3. Gamma-ray spectroscopy of three radioactive stones from table 1.

Sample no.	Color and type	Radio-activity ^a	Radio-activity ^b (nCi/gm)
GR ₁	Greenish yellow spinel triplet	1.5	0.44
GR ₂	Yellow-green spinel triplet	1.5	0.38
SW ₂	Yellow-green glass chaton	4	4.0

^aTimes background, as in table 1.

^bAs determined by gamma-ray spectroscopy; error $\pm 20\%$.

U.S. government limits, they probably present no hazard under normal wearing conditions. The dealer who carries a large parcel of such materials in a pocket for a prolonged period of time may, however, be at some risk. Since similar colors can be produced in glass without the use of uranium, it is difficult to understand why uranium-containing glass is still being used in jewelry today.

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