Gems & Gemology

SUMMER 1977

RICHARD T. LIDDICOAT, JR.
Editor

ROBERT A. P. GAAL, Ph.D.
Assoc. Editor

ISSN 0016-62X

GEMS & GEMOLOGY is the quarterly journal of the Gemological Institute of America, an educational institution originated by jewelers for jewelers. In harmony with its position of maintaining an unbiased and uninfluenced position in the jewelry trade, no advertising is accepted. Any opinions expressed in signed articles are understood to be the views of the authors and not of the publishers. Subscription price $8.50 each four issues. Copyright 1977 by Gemological Institute of America, 1660 Stewart Street, Santa Monica, California 90404, U.S.A.

gems & gemology

VOLUME XV *NUMBER 10*

SUMMER 1977

IN THIS ISSUE

Contribution to the Gemological Analyses of Argentine Fluorite

BY DR. J. C. FUENTES AND LIC. R. TUCCILLO
Laboratory of Gemology
Banco Ciudad de Buenos Aires

Introduction

Fluorite, a name of Latin origin, means "flowing rock" and has been in use since Roman times (Wollin, 1972). Alternately, "flux" is the name applied in industry and ornamental stone or gemological material of normal use for the beautifully colored varieties. Fluorite appears quite frequently as an accessory mineral of several ore deposits in Argentina. During the present work, some samples have been selected from different districts, like Córdoba, San Luis and Rio Negro provinces. (See *Figure 1.*) These samples have been compared with others from well-known localities such as Durham and Castleton in Derbyshire, England (Ford, 1955).

These samples were subjected to gemological analyses, i.e., refractive index, specific gravity, X-ray and ultraviolet-light fluorescence, thermal treatment, and chemical analyses of trace elements by emission spectroscopy.

Paragenesis

Generally, Argentine fluorite occurs in hydrothermal veins of low temperature, in bodies up to one kilometer long and 0.3 - 3.0 meters wide. In some ore deposits it appears in cracks or breccias connected with granitic rocks and schists (Angelelli, 1950).

Veins are commonly fiber-like or fine-grained. The color varies widely, ranging from white, violet, green to yellow. The mineralogical association is mainly calcite, barite, chalcedony, etc. Generally, Argentine fluorites are not associated with sulphides; some deposits of fluorite are associated with tungsten (W) mineralization (sample No. 6).

Physical Properties

The refractive indices were obtained by using a GIA Duplex II refractometer, with a monchromatic light source (yellow sodium light). In order to get the specific gravity, the pycnometer method was used, obtaining a range from 2.80 to 3.18. The lower values are probably due to the quartz inclusions in the samples (see *Table I).* Fluorite belongs to the isometric system (Zussman *et al.,* 1970) and its hardness is 4 in the Mohs scale.

The ultraviolet analyses were made

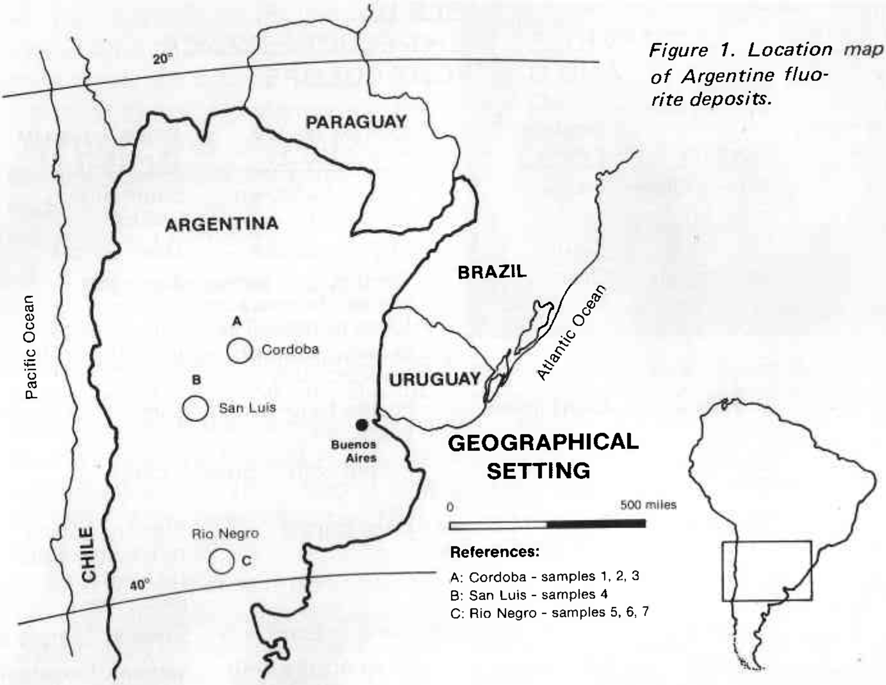


Figure 1. Location map of Argentine fluorite deposits.

with a Chromato-Vue CC-20, an instrument having both short and long wave sources (see *Table II).* X-ray fluorescence and phosphorescence were run using a Reich-Scheiffer machine. See results in *Table III.*

Chemical Properties

The basic composition of fluorite is calcium fluoride (CaF_2). Usually, it contains some trace elements quite important to the optical and physical properties of the mineral. Therefore,

TABLE I
REFRACTIVE INDEX AND SPECIFIC GRAVITY

Sample No.	Locality	Refractive Index (Na = 5890 Å)	Specific Gravity (g/cm^3)
1	Pampa Olaen	1.438	3.080
2	La Ciénaga	1.434	3.120
3	La Ciénaga	1.433	3.180
4	Río Seco	1.433	3.176
5	Los Menucos	1.435	3.110
6	Valcheta	1.441	2.990
7	Pailéman	1.435	2.799
8	Durham	1.432	3.160
9	Blue John	1.435	3.250

TABLE II
ULTRAVIOLET-LIGHT FLUORESCENCE AND DAYLIGHT COLORS

Sample No.	Locality	Daylight Colors	Long-wave UV (λ = 3660 Å)	Short-wave UV (λ = 2537 Å)
1	Pampa Olaen	White	Purple to brown yellowish	Same but weaker
2	La Ciénaga	Purple	Slightly purple	Deep purple
3	La Ciénaga	Deep to light purple bands	Deep purple gives purple fluorescence. Light purple gives brown yellowish fluorescence.	Same but strongest fluorescence in light purple
4	Río Seco	Light green	Purple to brown yellowish	Same
5	Los Menucos	Light brown slightly yellowish	Purple with "zones"	Same
6	Valcheta	Purple to brown yellowish bands	Deep purple	Slightly purple to cream white (Scheelite's impurities)
7	Paileman	Same as Sample 6	Same as Sample 6	Same as Sample 6
8	Durham	Colorless	Deep purple with strong "zones"	Same but weaker
9	Blue John	Purple banding	Very weak slightly purple	Same

TABLE III
X-RAY FLUORESCENCE AND PHOSPHORESCENCE TUNGSTEN (W) TUBE, 53 kv. AND 20mA.

Sample No.	Locality	Fluorescence	Phosphorescence
1	Pampa Olaen	Strong bluish green	Strong and permanent
2	La Ciénaga	Cream purple	Non-present
3	La Ciénaga	Cream purple	Non-present
4	Rio Seco	Light yellowish brown	Strong and permanent
5	Los Menucos	Light purple	Weak and brief
6	Valcheta	Light purple	Weak and brief
7	Paileman	Purple	Weak
8	Durham	Light blue	Weak and brief
9	Blue John	Cream purple	Non-present

we put emphasis on the research of these elements which may substitute partially for the calcium, yttrium (Y), cerium (Ce) and strontium (Sr). The qualitative and semi-quantitative chemical analyses of the samples were made with a "Spectrex" Vreeland 6 spectroscope (see *Table IV).*

Discussion of the Results

According to the X-ray, ultraviolet fluorescence and phosphorescence, microscopical aspect and natural color, there is a remarkable similarity among fluorites from La Ciénaga (Córdoba), Valcheta-Pailemán (Río Negro) and the Blue John from Castleton (England).

Blue John color is believed related to an organic origin, suggesting synchronous formation of the fluorite with oil-bearing sediments (Ford, 1955). Similar evidence of this type was found in the Argentine specimens. Besides, there might be a possible connection between Durham (England) and Los Menucos fluorites (Río Negro) on the basis of physical properties (see *Table II).* Both types show strong "zones" under ultraviolet radiation (see *Figure 2).*

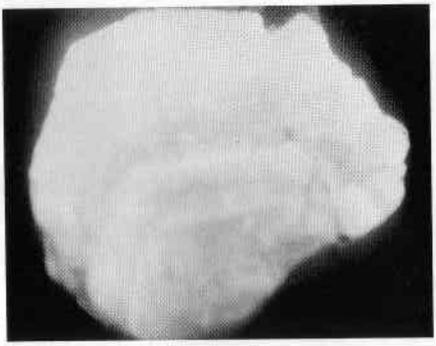


Figure 2. Los Menucos' fluorite (Sample 5) showing strong "zones" under U.V. light.

Some fluorite under thermal analyses (I.E. Qda. del Rio Seco, S.4) have shown strong remnant phosphorescence. All samples were decolored by heating (Fander, 1972) followed in many samples by a decrepitation effect, probably due to expansion of some water in the crystals.

Conclusions

The best Argentine fluorites for gemological or ornamental purposes

TABLE IV
SPECTROSCOPIC ANALYSES

Sample No.	Locality	Cerium	Yttrium	Strontium
1	Pampa Olaen	traces	contains	traces
2	La Ciénaga	traces	traces	more than 1%
3	La Ciénaga	traces	traces	less than 1%
4	Río Seco	contains	traces	traces
5	Los Menucos	contains	contains	less than 1%
6	Valcheta	traces	traces	less than 1%
7	Pailemán	————	traces	less than 1%
8	Durham	traces	traces	traces
9	Blue John*	————	0.02%	traces

*After "Blue John fluorspar," T.D. Ford, 1955.

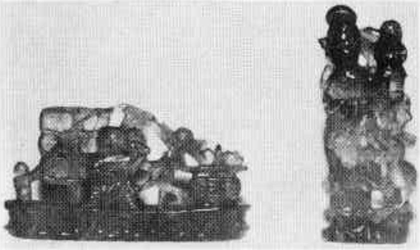


Figure 3. Carved figures made of Argentine fluorite.

are the green specimens found in San Luis Province (Qda. del Río Seco) and the banded violet ones from Córdoba (La Ciénaga). *Figure 3* shows carved figures of Argentine fluorites. Recently, some green fluorite simulants have appeared in the local market, made of plastic material (see *Figure 4)* and is used as ornamental figures. The fidelity of the natural "matrix" reproduced in the imitation fluorite can hardly be recognized as a simulant even after a hardness test or fluorescence assay. The other fluorites, mainly the purple color and the banded ones quite similar to Blue John, have problems as ornamental stone because it is difficult to carve.

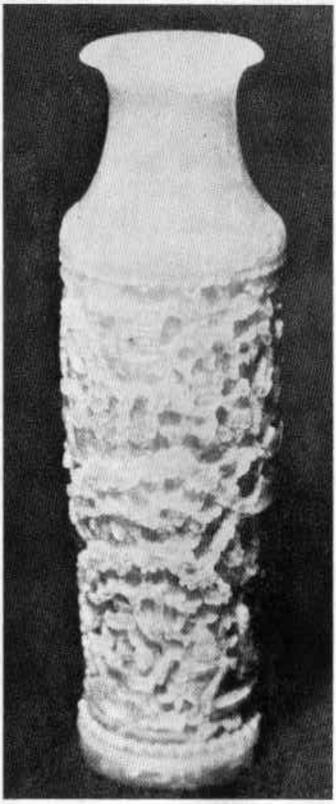


Figure 4. Remarkable simulation of green fluorite made of plastic material.

Acknowledgments

Particular thanks are due to Banco de la Ciudad de Buenos Aires and the Geology Department of the University of Buenos Aires, for providing working facilities and specimens of fluorite.

References

Angelelli, V., (1950) "Recursos Minerales de la República Argentina" *Rev. Museo C. Naturales, B. Rivadavia, Vol. I.*

Fander, H. W., (1972) "Fluorite." *Australian Gemmologist, XI 6, 25.*

Ford, T. D., (1955) "Blue John Fluorspar." *Middlesborough, Proc. Yorks. Geol. Soc. Vol. 30.*

Montoriol-Pons, J., (1969) "Nota sobre la fotoluminiscencia de la fluorita." *Boletín de la Asociacion Española de Gemología. Vol. II, No. 3 and 4.*

Wollin, J. C., (1972) "The rainbow mineral fluorite," *Mineral Digest, Vol. 4.*

Zussman, J. R. A., Howie and N. A. Deer, (1970) "An introduction to the rock forming minerals." London, Longman.

Developments and Highlights at GIA's Lab in Santa Monica

By RICHARD T. LIDDICOAT, JR.

During the past few months, we have encountered some very interesting items in Chuck Fryer's Santa Monica Laboratory. One of the most interesting was a colorless 10.28-carat square emerald cut stone. As expected in a colorless stone, it showed no absorption spectrum. The refractive index was above 1.81. Chuck found a uniaxial figure and determined a specific gravity of 6.13, with an accuracy of about ± .02. The X-ray fluorescence was moderate yellow. The short-wave ultraviolet fluorescence exhibited a strong yellow color. Under long-wave ultraviolet, there was a very strong yellow fluorescence and weak yellow phosphorescence. Given this information about the stone pictured in *Figure 1*, Mr. Fryer identified the stone as phosgenite. He was able to confirm this identification by using X-ray diffraction. This is the first phosgenite we have tested in any of the GIA Laboratories.

Other rare and unusual gemstones were examined during recent months. One was a 41.7-carat ekanite, the largest that we had ever seen. This square emerald cut stone was exceedingly radioactive and would have been very dangerous for anyone to wear. The inclusions observed in the stone are shown in *Figure 2*.

The third really unusual stone observed was a 48-point, slightly reddish brown cat's-eye that had a very sharp eye. It is pictured in *Figure 3*. This stone showed tourmaline properties in that the refractive index appeared to be on the order of 1.63-1.65 and the specific gravity near 3.15. The eye was sharper than any we had ever

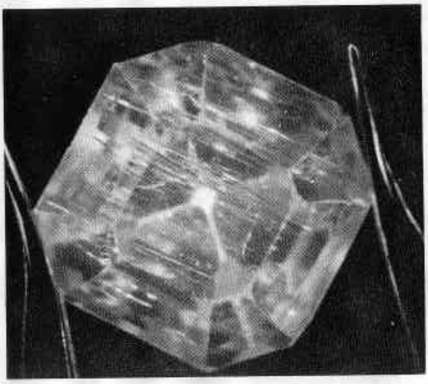


Figure 1.

Figure 2.

seen in tourmaline. The stone was inert to both long- and short-wave ultraviolet and to X-ray. It showed a band at 5100 Angstroms and a weaker band at 5500. Mr. Fryer was able to obtain a tiny amount of powder from it by scraping an edge (an amount I'm sure only Fryer's technique would have accomplished). With the diffraction pattern, we were able to identify the stone as our first anthophyllite.

Another unusual stone we tested was a green cabochon that showed a dye spectrum. There was a broad band absorption in the red in the area that we associate with dye in jadeite or nephrite. The specific gravity was about 2.94, the refractive index about 1.62, and the hardness about 4-1/2 to 5. The appearance was that of jadeite but the properties certainly could be confused with nephrite. Ultraviolet and X-ray fluorescence were quite different, however. Long-wave ultraviolet showed a bluish fluorescence as did short-wave ultraviolet and the X-ray fluorescence was yellowish. Scraping material for an X-ray diffraction analysis revealed that the material was dyed wollastonite. The stone is shown in *Figure 4.*

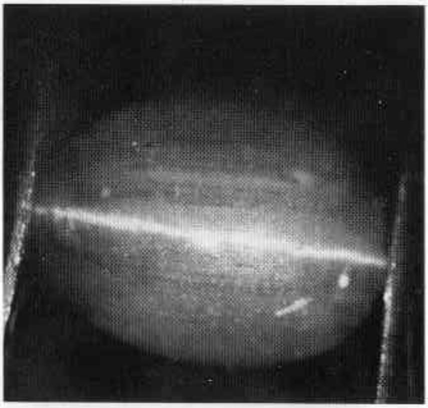


Figure 3.

Diamond Items of Interest

Recently, we found an unusual inclusion under the table of a diamond that was brought in for testing. It was an included macle with rather peculiar surface markings. This is shown in *Figure 5.*

Another diamond showed purple banding or grain lines. These are

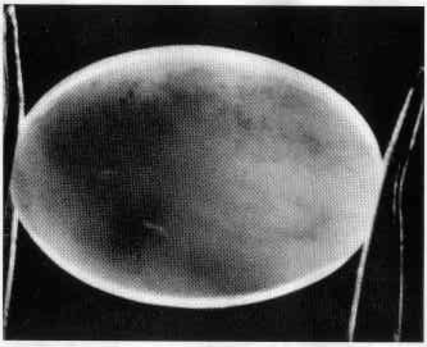


Figure 4.

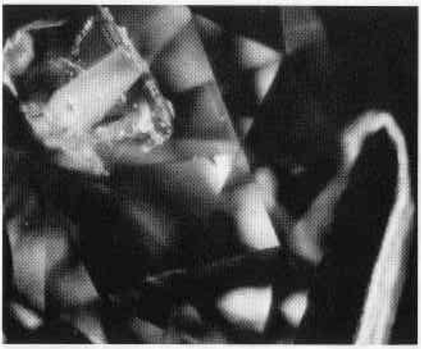


Figure 5.

shown near the girdle in *Figure 6.* We do not recall having seen grain lines or banding in the past with a purple color in diamonds.

In a treated yellow diamond, we found a large indented natural on the pavilion. This interesting feature is pictured in *Figure 7*, taken at 22x. Obviously, the stone was not considered exceedingly valuable to be left in this condition.

Figure 8 shows a diamond with two spots of ink, one at 12:00 o'clock and the other at 6:30. The ink had been placed on the diamond, obviously to improve the apparent color. With the ink on the stone, it was graded at a low H; with the ink removed, it was on the I-J borderline. The ink spots are shown in *Figure 8.*

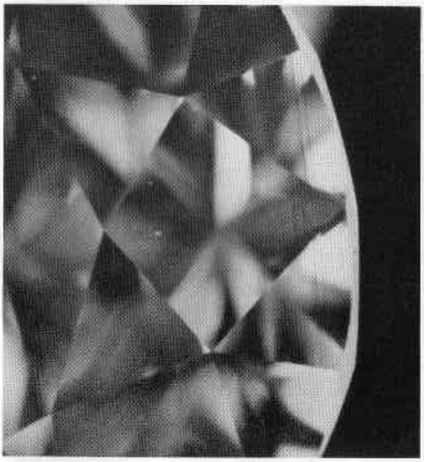


Figure 6.

Another diamond was sent in for identification because it had been so badly abraded on the crown that the sender could not believe the diamond could be so badly worn, and questioned its identification. It is shown in *Figure 9.*

One of the problems that we fre-

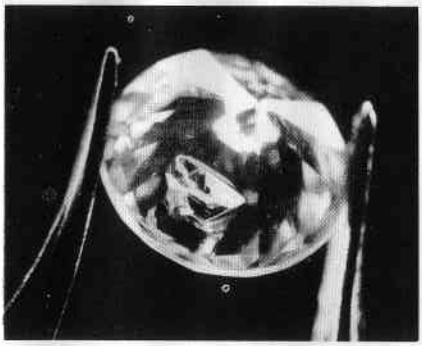


Figure 7.

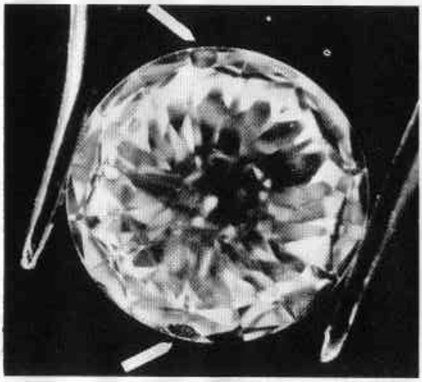


Figure 8.

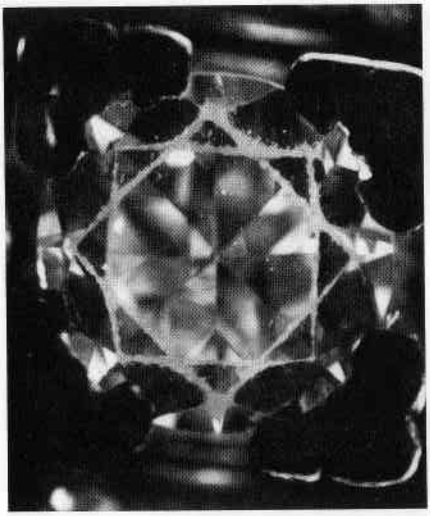


Figure 9.

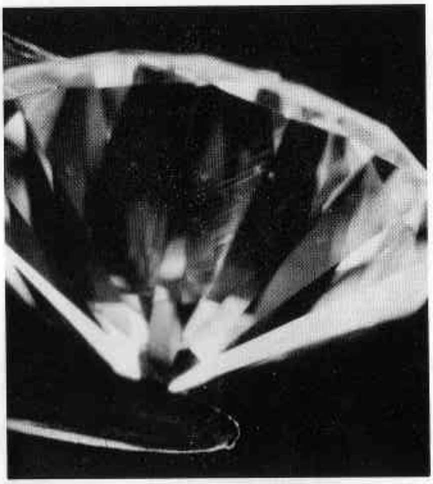


Figure 10.

quently encounter in diamond grading is a matter of grain lines. When grain lines are visible only through the pavilion and do not cause any whitening or reflections, they are noted under graining, but do not reduce the clarity grade. When they are reflective or whitish, they do affect the clarity grade. Some prominent grain lines are shown in *Figure 10.* If these were

Figure 11.

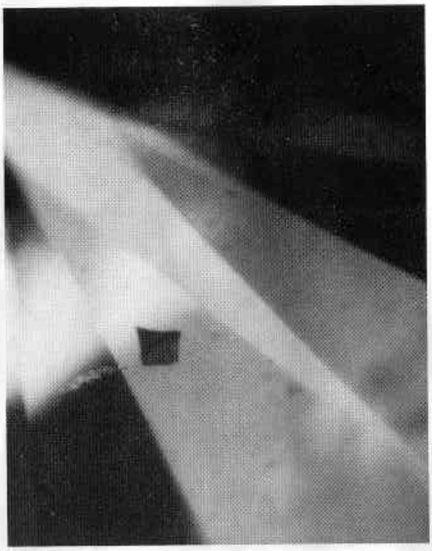


Figure 12.

polishing marks, as they appear at first glance, they would not extend across facet edges. These lines are seen internally and are obviously more significant than a tiny pinpoint. The grain lines visible in *Figure 10* definitely would reduce the clarity grade of the diamond.

An intriguing negative crystal was found on the surface of a diamond that recently came in for quality grading. In *Figure 11,* in the dark background, the inclusion appears as an included crystal. However, it was at the surface and undoubtedly had been pulled out during the polishing process. Another view is seen in *Figure 12.* Both shots were taken at 126x.

Acknowledgments

We wish to express our sincere appreciation for the following gifts:

To *Fred Alter,* of Karten's Jewelers, Nashua, New Hampshire, for a useful selection of miscellaneous stones.

To *David Bojar*, Gemologist, GIA correspondence student, Providence, Rhode Island, for a generous gift of 288 natural, synthetic and imitation cut stones that will be put to good use in our courses.

To *E. Braunschweiger,* GIA correspondence student, Morristown, New Jersey, for an assortment of garnet and glass doublets and other stones needed for our gem identification classes.

To *Robert Flower,* Gemologist, of Sonflower Corporation, Junction City, Kansas, for a group of nice cabochon cut black star sapphires.

To *J. Frank Golden,* G. G., of J. Frank Golden & Associates, Inc., Forest Park, Georgia, for an interesting 3.42-ct. prosopite, and five "osmena pearls."

To *Ben Gordon,* G. G., of Gordon Jewelry Corporation, Houston, Texas, for yet another grand assortment of natural, synthetic and imitation gem material, all of which will be put to good use by our students.

To *Patricia Haney,* G. G., of Gems Galore, Mountain View, California, for a selection of synthetic and imitation stones and a garnet with unusual inclusions.

To *William D. Harper,* Gemologist, of Harper's Jewelry, Inc., Montgomery, West Virginia, for a nice specimen of topaz and ruby for the gem identification course.

To *Thomas L. Hawk,* of Thomas L. Hawk – Jeweler, Columbus, Ohio, for a large paper of miscellaneous stones that once belonged to the late Mel Hohenstine, C. G. These will be put to good use by our students.

To *Steven L. Henderson,* G.G., of Nathans Jewelers, Ltd., San Angelo, Texas, for a cluster setting with 7 YAGs and 8 miscellaneous cut stones.

To *Shu Hoochi,* of Hong Mei Coral Jewelry Factory Company, Ltd., Taipei, Taiwan, for a welcome gift of 31 pieces of coral.

To *Larry Isgrig,* GIA student, Sarasota, Florida, for a nice piece of rough opal, a natural blue sapphire, a garnet, and a garnet and glass doublet.

To *Burton Joseph,* of Josephs' Jewelers, Des Moines, Iowa, for a useful collection of various cut stones for our practice sets and a light blue star sapphire for class use.

To the *Juergens and Anderson Company,* Chicago, Illinois, for a generous gift of numerous natural rubies, a natural blue star sapphire, natural emeralds, an opal, two red tourmalines and a fine topaz.

To the *Dorothy L. Kellogg Estate,* Olive, California, for two pink Royal Gem "imitation pearls" measuring 8.65 mm. and 5.1 mm., respectively.

To *E.S. Love,* GIA student, Newport News, Virginia, for a welcome assortment of rough, cut and cabochon gem materials which include several pieces of lapis-lazuli, amazonite, chrysoprase, amethyst, turquoise, kunzite, quartz and three cut synthetic corundums.

To *Mr. and Mrs. V.R. Martin,* gem enthusiasts extraordinaire, Glendale, California, for a very generous gift of a large, fine quality emerald cut green beryl from Brazil, weighing 155.64 cts., for our new gemstone museum collection.

To *Don Melby,* of Melby's Jewelers, Santa Maria, California, for an unusual beryl triplet with an aquamarine color.

To *Bill Mosher,* G.G., of Mosher's Jewelers, Port Huron, Michigan, for a selection of much-needed miscellaneous cut and rough stones for class use.

To *Patric H. O'Steen,* GIA correspondence student, Ozark, Alabama, for a damaged diamond which will be used as a recutting problem in the diamond course.

To *Guy Paul,* G. G., and *Larry Gray,* of One Track Mines, Inc., Reseda, California, for a selection of 14 fire agates.

To *R. S. Peebles,* G. G., Minden, Nevada, for a welcome assortment of miscellaneous rough and cut stones including jadeite, natural emeralds, turquoise, garnet, garnet and glass doublets and dyed quartz.

To *Bernice Perer,* Kowloon, Hong Kong, for an assortment of natural opal cabochons, tourmaline and iolite cut stones.

To *Ed Quigley,* GIA resident student, of Redearth Trading Company, San Diego, California, for three unusual pieces of dyed magnesite.

To the *Ronox Corporation,* Los Angeles, California, for a donation of four Russian alexandrite crystals in matrix.

To *Mr. Joseph H. Samuel, Jr.,* GIA student, of J. & S. S. DeYoung, Inc., Boston, Massachusetts, for a generous gift of a magnificent emerald cut Morganite weighing 29.16 carats. This important contribution will be a feature of our collection to be enjoyed by our students and staff for years to come.

To *Tim Smith,* G. G., of Daniel Smith Jeweler, Salem, Ohio, for a large collection of useful miscellaneous cut stones.

To *Rick J. Sorenson,* G. G., of Tavernier of Cherry Creek, Aurora, Colorado, for a very much-needed group of 30 faceted natural sapphires for test sets.

To *South Sea Sales,* Laguna Beach, California, for one lavender and one brown and white coral cabochon with a corresponding branch of the natural coral for each cabochon, a rough piece of blue coral, and two pieces of plastic coated blue coral.

To *Marcus Switzer,* of Switzer's School of Faceting, Manhattan Beach, California, for a rough zircon containing unusual tube-like inclusions with a very strong spectrum and a fine moonstone specimen.

To *Douglas Ward,* GIA correspondence student, of Wards' Jewelry, Sunriver, Oregon, for two nice rough examples of cat's-eye spodumene.

To *August Weilbach,* GIA student, La Habra, California, for a large piece of difficult to obtain optical quality calcite.

To *Charles Wells,* Jacksonville, Florida, for a beautiful colored picture of matched alexandrites and a welcome selection of miscellaneous stones for student use.

To *David Widess,* of I. Widess & Sons, Los Angeles, California, for a generous gift of early Gilson synthetic emeralds and the long-term loan of three fine diamonds used for student demonstration purposes.

In Memoriam

We are saddened by the death of Professor Ralph J. Holmes of the Department of Geological Sciences at Columbia University. Dr. Holmes was a long-time associate and friend of GIA. At one time he was an Advisory Board Member to the Gem Trade Laboratory and a regular contributor to Gems & Gemology. During summers in the late 1940's, he conducted classes for GIA, making many lifelong friends in the process.

Ralph Holmes is well remembered by the trade for his many contributions to gemology. Especially significant was his research in the identification of gems by X-ray techniques. Dr. Holmes was a Professor of Mineralogy and Crystallography at Columbia University from 1936, and taught a well-known course on Gems and Precious Stones in the University extension classes.

Those who knew him will remember with gratitude his gift for teaching, his warm-hearted friendship and his lasting interest in gems and minerals.

CORRECTION

In a recent paper on the Slocum stone *(Gems & Gemology,* Volume XV, Number 8, pages 252-256), the words *opalescence* and *opalescent* were inadvertently misused to denote the play-of-color in opal and some opal simulants. The word opalescence correctly refers to the milky or somewhat pearly appearance of some opals, but not to the well-known play-of-color seen in fine gem opal. The author regrets the error and wishes to thank Dr. Kurt Nassau for calling his attention to the misuse of the words.

Pete J. Dunn
Dept. of Mineral Sciences
Smithsonian Institution
Washington, D.C.

L_H —

A New Gemological Property

By W. W. HANNEMAN, Ph.D.
President, Hanneman Gemological Instruments
Castro Valley, California 94546

Luster can be defined as the appearance of a surface as determined by its reflecting power. L_H is the term used to define the numerical value for luster as determined according to the method of the author. This article presents a description of the evolution of an instrument providing numerical values for luster, a table of L_H values for gems and a practical scheme for the identification of the high RI simulated diamonds.

The reflecting power of a surface is determined by several factors. They are the chemical composition and atomic structure, the degree of smoothness (polish), and the cleanliness of the surface as well as the wavelength of the energy source used to make the measurement.

Gemologists, dealing with polished specimens, are in a position to minimize or recognize any negative effects of surface polish or dirt. This leaves the major factors affecting the reflecting power of a gem to be its chemical composition and atomic structure and the wavelength of incident light. This was recognized by the author and resulted in the creation of the pocket sized, portable Hanneman Relative Reflectometer which is perhaps better known as "The Jeweler's Eye®." In this instrument energy emitted from a gallium arsenide light emitting diode was used rather than either monochromatic sodium or white light as the longer wavelengths served to somewhat decrease any effects of surface roughness and to provide the desirable separation of diamond from strontium titanate.

"The Jeweler's Eye®" is calibrated to relate the quantity of reflected energy to the name of the gem (i.e. chemical composition and atomic structure). A typical scale is shown in *Figure 1.*

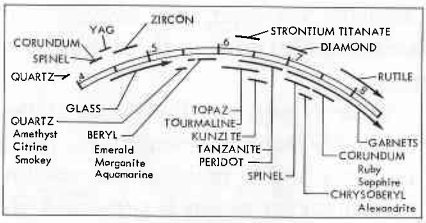


Figure 1. A typical scale.

TABLE I
THE HANNEMAN LUSTER SCALE*

Standard Gem	L_H
DIAMOND	4
STRONTIUM TITANATE	3
GGG	2
YAG	1
SYNTHETIC SPINEL	.73
QUARTZ	.55

*The scale is discontinuous below 1.

This has caused problems for the inexperienced individual, who, not understanding the limitations of reflective measurements, put "blind faith" in the meter reading. His confidence was, of course, shattered when he observed that any gem could give any reading below its designated range due to the condition of the surface and it was *his* responsibility to ascertain the suitability of the surface *before* making the measurement.

An analysis of this situation led to the conclusion that the relative reflectometer actually measures the property we know as luster. Now, since one can measure luster and "The Jeweler's Eye®" has demonstrated the usefulness of such measurements on gems for which it has been calibrated, it follows that if there were a numerical scale of luster and numerical luster values determined for all the gems, an instrument measuring luster could become a useful tool of determinative gemology. And so the LUSTERMETER® was conceived.

Since there was no recognized scale

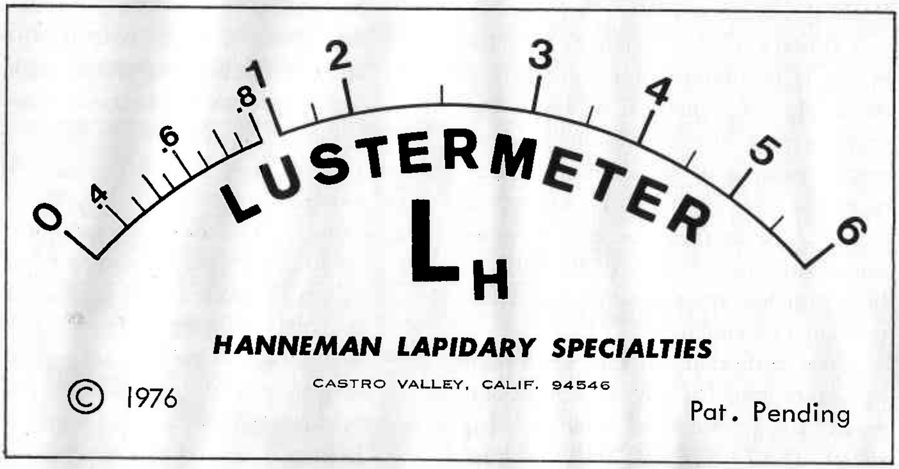


Figure 2. A typical LUSTERMETER® scale.

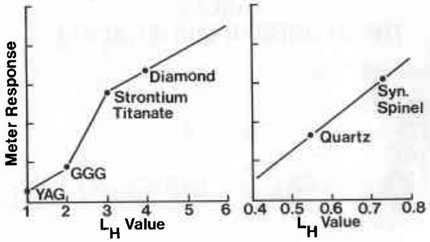


Figure 3. Typical curves for calibration for L_H values.

for gem luster it was first necessary to create one. From an analytical viewpoint, it is much simpler to make relative measurements than absolute determinations; so it is only sensible to create a relative scale of luster. This has been done and is shown in *Table I.* It is similar in concept to the Mohs Scale of Hardness. It has been named the Hanneman Luster Scale and values are designated by the symbol L_H in order to specify it is based on measurements using the gallium arsenide LED energy source. A typical LUSTERMETER® scale is shown in *Figure 2.*

Calibration of a relative reflectometer is accomplished by creating a linear plot of numerical values as the abscissa and the maximum possible meter readings of the reference specimens as the ordinate as shown in *Figure 3.* Since these are relative measurements, the accuracy of the calibration depends upon the quality of the reference specimens.

Once calibrated, L_H values can then be determined for any gem and compared to a reference table of L_H values. The LUSTERMETER® is most useful for the identification of the simulated diamonds not amenable to critical angle refractometer measurements.

Table II presents L_H values of the reasonably scratch resistant diamond simulants and a practical scheme for their characterization is presented below.

A higher measured luster value indicates the supposed identification is incorrect. A lower value does not positively rule out the purported identity unless it can be shown that the surface condition is *not* significantly lowering the LUSTERMETER® reading.

If the measured L_H value falls in a range covered by more than one gem, then additional data must be obtained in order to make the proper identification.

An examination of *Table I* reveals some very useful and practical generalizations which can greatly simplify the gemologist's task. Several of these are noted below.

- Except for diamond and silicon carbide, all gems having L_H values above 2.5 are soft ($H<6$) and/or doubly refractive with high and easily observed birefringence.
- Except for andradite garnet (with its characteristic inclusions), there are no naturally occurring gemstones having L_H values between 1 and 2.5 which are singly refractive.
- All synthetic garnets are singly refractive and have L_H values between 0.7 and 2.5.
- Diamond, zircon and sphene are the "most apt to be encounter-

TABLE II
HANNEMAN RELATIVE LUSTER VALUES

Material	L_H	Hardness Mohs	Distinctive Features
Silicon Carbide	5	9+	Brown to green; Low birefringence
Rutile	4.5-5+	6-6.5	High dispersion, High birefringence
Anatase	4.5-4.7	5.5-6	Tetragonal; High birefringence
Diamond	4	10	Isometric
Stibiotantalite	3-4	5	Orthorhombic
Strontium Titanate	3	5-6	Isometric
Sphalerite	2.9	3.5-4	Very high dispersion; Cubic
Lithium Niobate	2.4	5.5	Isometric
Zirconium Oxide	2.2	8.5	Isometric
Zincite	2	4-4.5	Hexagonal
GGG	2	6.5	Isometric
Cassiterite	1.9-2.3	6-7	High dispersion; Tetragonal; High birefringence
Zircon (high)	1.7-2	7.5	High birefringence
Sphene	1.4-2	5-5.5	High birefringence
Yttrium Aluminate	1.7	>7	Lower birefringence
Scheelite	1.5-1.6	5	Tetragonal; Fluoresces
Zircon (medium)	1.4-1.7	7.5	High birefringence
Andradite Garnet	1.3	6.5-7	High dispersion
YAG	1	8	Isometric
Zircon (low)	<1	6.5	Usually green
Synthetic Garnets	<1-2.3	6.8	Isometric

ed" natural gemstones with L_H values above 1.5. Any other gem with L_H above 1.5 is either a man-made product or else a relatively soft and rare "collector's item."

From a practical point of view, once a simulant has been recognized, the precise identification of its composition is purely an academic question as the intrinsic values of all the synthetics are small.

To be sure, the LUSTERMETER® does provide values between .4 and .8 which include most of the traditional colored gemstones. However, it is recognized that more useful diagnostic information can be obtained by the gemologist using his critical angle refractometer. Nevertheless luster values have been assigned to all of these gems. They can be easily remembered as they correspond to the value obtained by removing the 1. from the RI value.

It is expected that other researchers having access to the rare "collector's item" high RI gems will be able to provide accurate L_H values for them and increase the overall utility of the LUSTERMETER® *(Figure 4)*.

Figure 4.

Developments and Highlights at GIA's Lab in New York

By ROBERT CROWNINGSHIELD

Notes On Fancy Colored Diamond

In recent issues of national jewelry trade magazines we have seen at least four advertisements for treated color diamonds. Several offer not only stock but the service of treating diamonds. This development seems to indicate a greater acceptance of treated diamonds but also indicates a greater need to review testing procedures. While pursuing the latter we have come upon several observations which are not covered in the G.I.A. Diamond Course or are in error.

In the past year we have seen more small treated pink to purple-pink diamonds than in all the years since we identified our first stone of .01 ct. Last year an exciting red-purple stone of nearly .75 carat was seen and found to have the typical absorption spectrum as shown in Liddicoat's *Handbook of Gem Identification.* We are indebted to New York diamond broker and Gem Trade Laboratory member Arthur Reik for securing on loan for our study a paper of more than 20 pink, yellow-pink, purple pink to fine light pink treated diamonds weighing as a lot nearly 3.00 carats – by far the greatest number we have seen at one time. It was comforting to see that they all had the typical absorption spectrum. We still do not know what type of diamond becomes this exciting color upon treatment. The fact that they have a "Cape" line at 4155 A.U. at first suggested that the stones must be some shade of yellow to greenish-yellow before treatment. Recent observations of a lot of rough Brazilian pink stones in which we detected the 4155 A.U. line in any stone that fluoresced blue in long-wave ultraviolet forced us to abandon that theory. We have not noted in the literature any mention of a "Cape" line in fluorescent pink natural color diamonds. Because the lot of pink rough was submitted to determine if the color was natural we scurried off to find known natural pink diamonds in established collections and can report that every stone tested which had medium to strong blue fluorescence also showed the 4155 A.U. absorption line.

In the past year or so we have issued individual color origin reports on a large number of natural color black diamonds as each was finished. We note a recent advertisement in which the stones are being promoted. Many of the stones were very difficult to polish and in some cases only the crown would be completed. We were told that polishing wheel life was short. Some of the stones were truly opaque but most exhibited some light transmission over a powerful light such as that used for the spectroscope. Some show a "sugary" appearance and light reflected from internal fractures appears white. Thus we can state categorically that the note formerly found in Lesson 18 of GIA's DIAMOND COURSE (page 3) was incorrect. If thin sections of a black diamond (or reflections from fractures) appear green, it is an excellent indication that the stone *is treated* – not natural.

An oversight in the course came to our attention recently when because of some unexplainable "hunch" the writer placed a large hexagonal step cut brown diamond on the conductometer and found that it conducted, but not uniformly. Most gemologists believe that no other than blue or gray diamond could show Type II$_B$ characteristics. The fact that stones which appear brown to the eye could be conductive seemed not to have gotten into GIA's lessons. In self defense the writer contacted Mr. Joseph Gill of J. & S.S. DeYoung, Boston, who is working on a master cross reference of topics in gemological and jewelry trade publications. In a matter of minutes while I was waiting on the telephone he came up with two entries in past issues of *Gems & Gemology* where this fact was noted – embarrassingly, by this writer. In these earlier references it was noted that these brown conductive diamonds seem to be laminated with alternating zones of Type II$_B$ and some other type. In one case, the zones were clearly alternating light blue and brown but the overall appearance was a peculiar brown – perhaps, though not necessarily, similar to the recently tested hexagon which was tested for conductivity.

We have long thought that the brown to yellow and greenish-yellow green transmitting diamonds which show two absorption lines at approximately 4980 A.U. and 5040 A.U. are distinct from those stones which show the "Cape" spectrum. It came as a surprise to examine a typical brown green-transmitting stone which showed in addition to the 4980 and 5040 lines the basic cape line at 4155 A.U. Similarly, we were surprised to see a distinct line at approximately 5700 A.U. from a yellow brilliant with an otherwise typical strong "Cape" spectrum. This measurement coincides almost exactly with the fluorescent line produced by ordinary fluorescent light. Interesting enough, we noted the line nearly 20 years ago as an oddity easily overlooked if any stray fluorescent light strikes the spectroscope aperture.

"Insect" In Diamond?

A truly enchanting inclusion in an

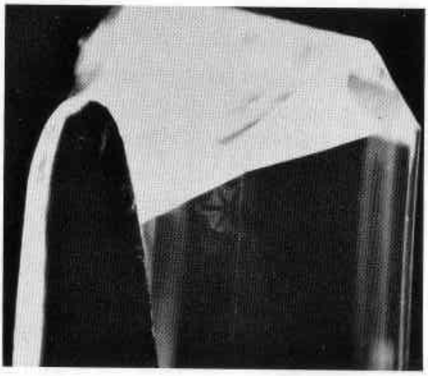


Figure 1.

emerald-cut diamond submitted for quality grading in illustrated in *Figure 1.* Although the "thing" has the usual six-fold symmetry we expect from such inclusions, one "ray" was long – the insect body, and one was short – the head. The remaining four were equal and approximated wings.

"Opal-Essence"

The choice of the name "Opal-Essence" for the marketing of the Slocum Stone discussed at length in an article by Mr. Pete J. Dunn in the Winter 1976-1977 issue of *Gems & Gemology* brings to mind the conflicting definition of the term opalescence on which the new terms play. In American gemology, it is defined as "The milky or pearly appearance of some common opal. Not to be confused with the *play of color* exhibited by precious opal *(Dictionary of Gems and Gemology,* Shipley)." However, in Anderson's *Gem Testing* we find: "A term used both for the milkiness of common opal and (more properly) for the milky iridescence seen in precious opal." While in Webster's *Compendium* we see: "a reflection of a milky or pearly light from the interior of a mineral. Also used by some as an alternative to iridescence." But in *Webster's* (Noah) *Unabridged 20th Century Dictionary, Second Edition,* we find: "Opalescence, the quality of being opalescent." "Opalescent, resembling an opal in play of colors – iridescent." One wonders why this common term cannot be standardized.

Figure 2.

Staff Meeting Report

On the last Friday of January we were delighted to have as our guest speaker for the staff gemologists Mr. Pete J. Dunn from The Smithsonian Institution. He spoke of his work on tourmalines. On the last Friday of February we enjoyed an informal talk and exhibition of antique jewelry by GIA Graduate and antique dealer, Thana Rich. *(Figure 2.)*

A Real Fooler

Figure 3 illustrates some peculiar inclusions in a synthetic spinel with a color none of us ever recalls seeing. It

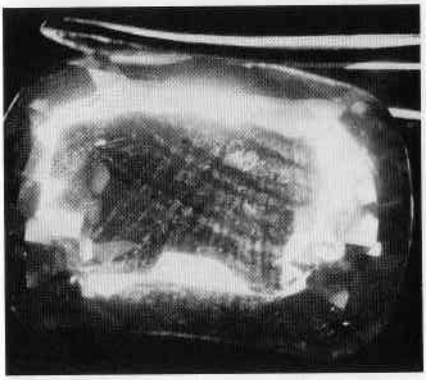


Figure 3.

resembles the pinkish-orange padparadscha variety of sapphire and was being offered with that label when a well-trained gemologist made the identification and sent it in for confirmation.

Phase Contrast Photography

Until recently we have been taking photographs of surfaces of stones suspected of having suffered damage using line-of-sight illumination with the Gemolite. Lately, we have been using a binocular microscope with Normarski phase contrast equipment. Even with the possibility of studying surfaces up to 2000x, extremely well polished stones with a fracture reaching the surface may not yield the needed information. However, under high magnification using different filters although no interrupted polishing lines are seen, undercutting on inherent fractures may be detected. In *Figure 4* an inherent fracture is seen under 300x. The lighter areas along the fracture show the direction away from the polish direction.

Figure 5.

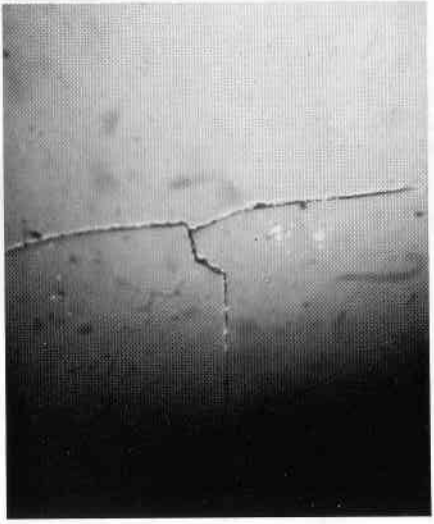


Figure 4.

More Diamond Inclusions

Figure 5 shows some unusual oriented needle-like inclusions in a 3.00-carat round diamond brilliant. Perhaps one day we shall encounter a diamond with enough needle-like inclusions to suggest cutting a cat's-eye – only who will cut a diamond cabochon? *Figure 6* is an attempt to capture a charming scene in a round diamond – a fish about to engulf a morsel with rays of sunlight off to the left. *Figure 7* is a picture of a .40–ct. diamond brilliant with the largest

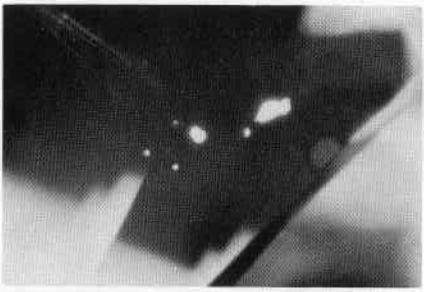


Figure 6.

naturals we have yet seen. One wonders about the weight retention from the rough. One would not expect to see a conchoidal fracture on a polished diamond or other stone with perfect cleavage. However, in *Figure 8* we see a good example of a conchoidal fracture. (We have seen the same thing on a blue topaz – probably treated – which prompted the owner to have the stone tested.) The included crystal in the diamond photographed in *Figure 9* resembles a child's face. In *Figure 10* a rare cubic natural was captured.

Beryl Oddities

In the black and white photograph, *Figure 11,* it was impossible to capture what looked like swirling snow over the Rockies in a parti-color (green and colorless) emerald.

Figure 7.

We have occasionally mentioned in this column the still unsolved phenomenon of "tarnish" on natural emeralds. Sometimes it is so heavy that it is impossible to secure a refractive index without polishing it away with a fine paper or ink eraser. It was not unexpected to see "tarnish" on a large golden beryl as seen in *Figure 12.*

Quartz-Natural And Synthetic

We were able to purchase for the Institute's collection two star quartz cabochons one of which was a light blue-gray and the other a pleasant smoky brown. The latter is shown in *Figure 13* looking down the optic axis.

Figure 8.

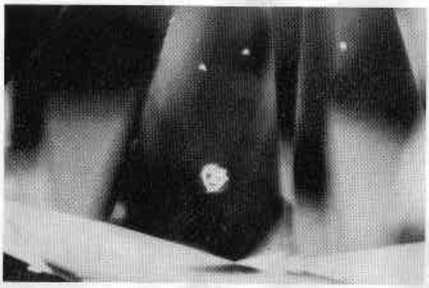


Figure 9.

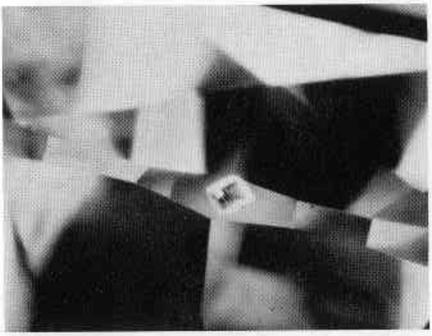


Figure 10.

When the stone was tilted slightly, numerous subsidiary stars appeared *(Figure 14)*. Under the microscope, additional stars terminating below the surface are visible. In all the writer counted 36 stars representing both four and six rays. The brown stone is unique in that it is without flaws under 10 power and the cause of the star is not seen under any magnification possible with the Gemolite. At first we thought the stones may have come from the same source in Alabama as the stones given to us by one Lucky McDaniels, a famous quick draw artist often employed by police academies – and owner of property on which he discovered normal quartz stars he was going to market as "StarFells." However, it was reliably reported that stones of this description had been bought in Sri Lanka, but we saw none until our good friend Eric Darmstadter brought us several from this locale. None, however, was as nearly flawless with as clear a phenomenon as the first we saw.

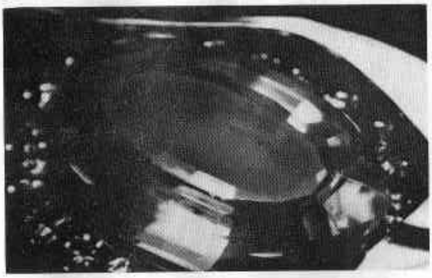


Figure 12.

Figure 11.

In *Figure 15* a bi-color synthetic quartz half yellow and half green is shown. We understand that it was made in the Soviet Union. Typical "bread-crumb" inclusions are seen in *Figure 16*.

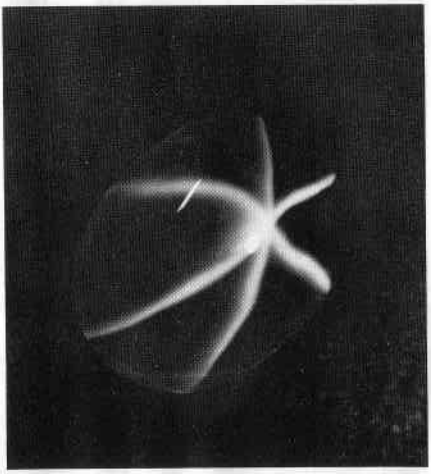


Figure 13.

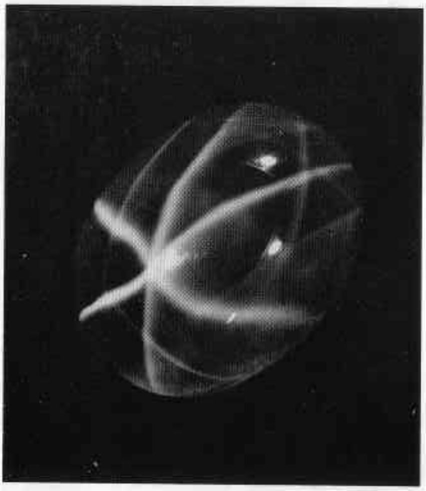


Figure 14.

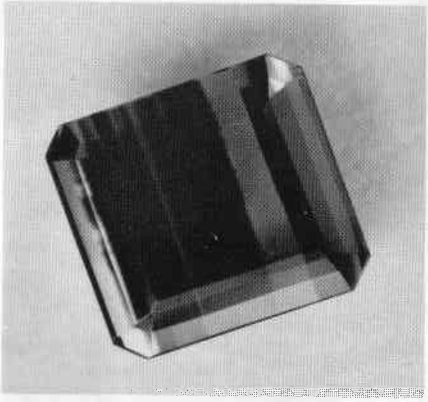


Figure 15.

A New Jewelry Item

Figure 17 cannot do justice to a hauntingly beautiful stone reported to be assembled with a rock crystal top laminated to fossilized ammonite in the form of aragonite with a supporting base. The stones we have seen are like a mosaic of green and red opal but clearly not to be confused. The one stone we have had to examine closely seemed very well made and the makers claim good durability. It has been named "Calcentine" in honor of Calgary's centennial. The fossil ammonities are found in southern Alberta and the stone is being manufactured by Calcentine Ltd. in Calgary. The plan is to sell only completed jewelry rather than unset stones. It is hoped that the jewelry trade will welcome a newcomer to a continent that unfortunately has precious few minerals we can count on to provide beauty for the marketplace in whatever form.

Figure 16.

More About Quartz

With the interest in emeralds at an all time high, qualities of this stone that would not have been cut years ago are appearing on the market. Some are quite good color but highly flawed and quite opaque. Into this breach has been thrown dyed quartzite that is an excellent imitation of this quality. Some has been sold on a buyer-beware

Figure 17.

basis while others have been labeled "Emerald Nova" which at least gives the wary a clue. Aside from the unnatural color, some of this material seen in the Laboratory has not been easy to test. Visually, the dye is not obvious but, of course, the absorption spectrum is wrong, thought due to chromium.

Acknowledgments

We wish to express our sincere thanks for the following gifts and courtesies:

To *Dr. Edgar F. Borgatta,* Ph.D., G.G., for a wide selection of gem materials selected from his firm, GemPro Distributors' stock, Rupert, Vermont.

To *Mr. Campbell Bridges,* Nairobi, Kenya, for some East African garnets valuable for research and study.

To *Mr. Eric Darmstadter,* Pelham, New York, for a selection of several stones including actinolite cat's-eyes for use in classes. In addition, we wish to acknowledge Mr. Darmstadter's good offices in securing for us unusual stones purchased while on trips to the Orient. Most recently we secured multi-starred quartz mentioned elsewhere in this column.

To G.I.A. student *Sy Ellenhorn* for a large selection of natural, synthetic and imitation gem materials for class and study purposes. We also wish to acknowledge the admirable welding he has done on the gemologists' hydraulic drafting stools in the Laboratory.

To *Mr. Samuel Goldowski* of Samuel Goldowski, Ltd., New York, for rough and cut examples of the new material being marketed as "Angel Skin Opal."

To G.I.A. Graduate *Ben Gordon* formerly of Gordon Jewelers, Houston, Texas, for an extensive selection of colored gemstones for resident class use.

To *Mr. Bill Kapelke,* Salida, Colorado, for a group of rough turquoise specimens form the Villa Grove mine nearby. The writer had three very nice cabochons cut from one piece.

To *Mr. Lewis Kuhn,* G.G., of the William L. Kuhn Co., Inc., New York City, for specimens of rough tanzanite for heating experiments.

To *Lipschutz & Gutwirth Co.,* New York, for several parcels of gemstones and synthetics for use in classes.

To *Mr. Dean McCrillis* of Plumbago Mining Corp., Rumford, Maine, for a selection of rough tourmaline from Mount Mica and Newry

tourmaline mines. We also wish to thank Mr. McCrillis again for welcoming resident class students and staff to his offices and mines. This delightful field trip helps round out the appreciation of gemstones the students need.

To resident class student *Elie D. Ribacoff* for tumbled stones for class use.

To *Mr. Ronald C. Romanella,* Scottsdale, Arizona, for some handsome treated blue topaz rough for study purposes.

To *Mr. Jedd Savel,* G.G., of L.I. Diamond and Jewelry Exchange, Garden City, New York, for two diamonds with unusual inclusions valuable for class study.

To *Mr. Maurice Shire,* Maurice Shire, Inc., for 16 round Sandawana emeralds badly needed for inclusion study sets for resident classes.

FLASHBACK

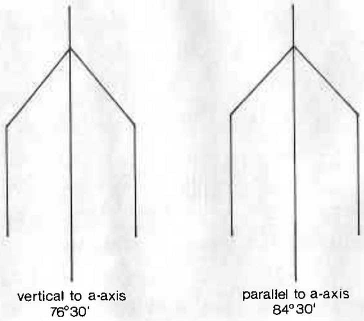
Ed. Note: One of the many rewards in publishing articles in *Gems & Gemology* is to have a reader's response to the material and adding more useful information to it. A recent example is described below from a letter by Dr. Edward Gübelin in which he shows that well-shaped inclusions can be determined by their measurable angles from a photograph.

"As always I read the developments and highlights from the GIA's laboratories with particular care and concentration and I was immediately struck by *Figure 11* on page 213 of *Gems & Gemology* (Fall 1976) showing the magnificent portrait of a quartz crystal in an emerald from Colombia. I am certainly not mistaken in assuming that we must have had (in our testing laboratory) this very emerald with this same inclusion, as I remembered it immediately. I took several photomicrographs from various angles very carefully because I had the feeling that such a beautiful and sharply-shaped crystal should allow me to measure its angles and thus determine its nature. Indeed, when measuring the angles of the crystal sketches which I had made from the photomicrographs, I found the typical angles of quartz, seen in the diagram below. The marked angles are constructed from the six-sided point. The positive and the negative rhombohedra are equally large. On freely grown quartz the point might even be blunt. As far as the morphology is concerned, the identity of our inclusion in this Columbia emerald is definitely quartz."

Most sincerely yours,

E. Gübelin

Dr. E. Gübelin, C.G., F.G.A.



On the Turquoise Deposits of Nishabur (N. E. Iran)

By MOHSEN MANUTCHEHR-DANAI
Faculty of Sciences, Geological Department
University of Meshed, Meshed, Iran

Abstract

A short description is given of the history, the output and the geological conditions of the turquoise deposits of Nishabur, together with some remarks on the genesis of the deposits. Turquoise appears together with faustite, the zinc analogue of turquoise, opal, and sulphides in weathered intermediate volcanic rocks (among others: trachyte and trachyandesite). The rocks are stained and darkened by iron oxide, and are ascribed to the Tertiary Age. Also uranium minerals (autunite) have been found.

Geographical Location

The turquoise deposits of Nishabur (36° 30′ N, 58° 20′ E) are situated approximately northwest of the town of Nishabur (in the direction of Tehran), near the village of Ma'adan *(Figure 1)*.

The only tunnels of the turquoise deposits worked today are on the south and southeast slopes of the Kuh-e-Raies Mountain (1250 m altitude; tunnel 1 is at 1675 m and tunnel 3 at 1575 m altitude), 2.5 kms west from the village. The neighboring summit of the Abdulrazzaghi Mountain is 1785 m high. The dumps of the mine are situated south of tunnel 3 *(Figure 2)*, and are visible from some distance.

Figure 1. General map indicating the geological position of the Nishabur deposits (from Tectonic Map of Iran).

History and Economics of the Turquoise Deposits

According to Pogue (1915) the world-famous turquoise deposits of Nishabur have been mined since 2100 B.C. An inscription at Susa from Darius the First (521 - 486 B.C.) mentions turquoise from the region known at that time as "Khawrazm." Khawrazm was an area located northeast of Iran with uncertain borders and probably the turquoise deposits were counted to Khawrazm.

In the 9th and 10th century A.D. also, several references to turquoise from Nishabur can be found in many old Persian gemmological, mineralogical, cosmological and medical manuscripts.

Marco Polo (13th century) and Tavernier (17th century) were among the first Europeans to mention turquoise from Persia in their travel accounts. Khanikov (1861), Tietze (1879 and 1884), Houtum-Schindler (1881 and 1886), Helmbacker (1898), Griesbach (1886 and 1887) wrote scientific reports about the turquoise deposits in Persia; Bogdanowitsch (1889) and Stahl (1911) discussed the possible geological formation of these deposits.

According to historical accounts, these turquoise deposits were known in Persian vernacular under the name of "Shadadi."

Since they were first discovered, the turquoise deposits of Nishabur have been worked in a very primitive way. (Later on the turquoise mine was modernized through the digging of three tunnels, and the ensuing transition to subterranean mining.) Today, the turquoise mine is still operating and it is run under state supervision.

The working area of the turquoise deposits extends over an area of nearly 1 km x 2.5 kms *(Figure 2).* There are at present about 210 people working at the mine. They extract approximately 11,000 kg of native rock – that is, from 4 to 4.5 m^3 per week. The turquoise is then extracted manually. According to calculations of the management of the mine, every ton of native rock has 3.3 kgs of turquoise, corresponding to 9 kg/m^3.

Geological Conditions and Age

The Kuh-e-Raies Mountain, from which the turquoise is extracted, consists of intermediate volcanic rock darkened by iron oxide. According to Tietze (1884), this rock belongs to the Tertiary Age. Bazin and Hübner (1969) state that it belongs to the early Tertiary. According to Griesbach (1886-1887), it must be ascribed to the Eocene with nummulitic limestone; this coincides with an Eocene origin.

The southeast slope of the mountain is covered by sediments composed of conglomerates, sandstones, nummulitic limestone, marl, gypsum and salt. Farther away, isolated salt hills are found towards the southeast. In the village of Amarlu, mineral salt is extracted.

The volcanic rock of this area runs from southeast to northwest, as can be seen from the geologic-tectonic map of Iran *(Figure 1).*

The rock complex consists partially of brecciated trachyte, i.e., trachyandesite of porphyritic texture. The

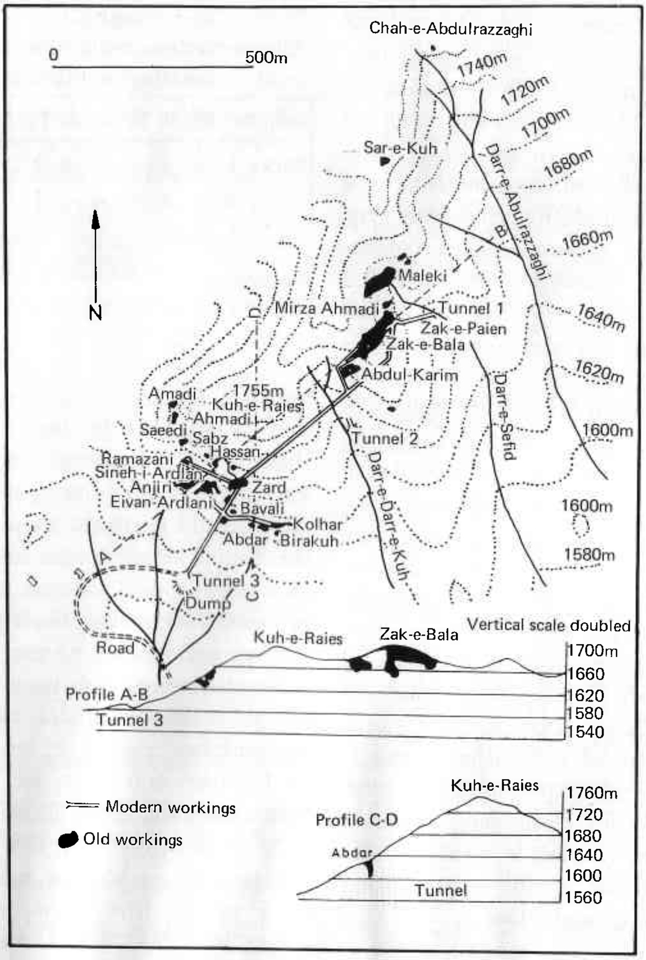


Figure 2. Morphological map of Nishabur deposits (from the former Mining Company of Nishabur prepared by the author).

weathered surface is yellow-brown to black-brown. The rock is alunitized. In places it has a gray to yellowish surface. This color appears paler on a freshly fractured surface. The alunite group of minerals consists of jarosite, natrojarosite and hydronium jarosite which can at times be seen in the fissures and on the fracture surfaces of the rock, and small turquoise grains also can be found there.

The actual brecciated brown rock containing turquoise is an extensively oxidized (limonitized) kaolinized siliceous trachyte with gradations to quartztrachyte and keratophyre. Sulphide minerals such as chalcopyrite, pyrite and probably sphalerite also appear in the rock as accessory constituents. The formation of sulphide minerals, according to Bazin and Hübner, can be most probably attributed to post-hydrothermal reactions. The turquoise yielding rocks are dark to black-brown on the surface, and yellow-brown on the fractured surface, and grade in places into gray with streaks of iron glance (specularite). The fissures and cracks in the brecciated rock are filled and veined with secondary iron oxide. It looks as though the iron oxide cemented the rock formation. However, there are nodular, nut- or pea-sized lumps of turquoise of different color shades in the cracks of the rock. All the rocks, the turquoise bearing as well as the non-turquoise yielding ones, contain apatite, which can be easily seen under the microscope. A greater proportion of apatite in the turquoise-rich mineral is confirmed by X-ray fluorescence analysis. These rocks contain between 1.3% to 3.0% of P_2O_5. Here it should be mentioned that colorless, radial, vitreous, shining secondary minerals, which were found in some of the cracks, proved to be apatite after radiographic examination.

TABLE I.
Elements detected in the Rocks and Weathering Products

Samples		Mn	Ni	Sr	Rb	Ba	Pb	As	Cu	Zn	Mo
Rocks	1	+	+	+	+	+	?	?	+	+	+
″	2	+	+	+	–	–	?	?	+	+	+
″	3	+	tr.	+	–	–	–	–	+	+	–
Weathering											
	1	+	–	+	–	–	–	–	+	+	?
	2	+	tr.	+	–	–	–	–	+	+	+
	3	+	tr.	+	–	–	–	–	+	+	tr.

Genesis

As already stated, turquoise forms nodular or pea-sized grains which appear here and there, in the cracks and fissures of the native rock (together with clay minerals, e.g., montmorillonite).

A previous paper on the turquoise deposits of Baghu (Manutchehr-Danai, 1976) indicated that the problem of turquoise formation has not yet been satisfactorily solved. Here one can accept the theory of turquoise formation, as described by Jung (1932) and Hinze (1933). The presence of secondary minerals, such as opal or chalcedony, could represent the evidence of the formation of turquoise as a weathering product. Some weathering products have been sampled from the fissures and cracks of the brecciated stone; these materials have a pale turquoise color, but under radiographic examination, proved to be aggregates of faustite* and turquoise. Thus, the rock must yield zinc minerals.

It is probable that this mineral is sphalerite (zinc blende), which occurs as a post-hydrothermal reaction, as described by Bazin and Hübner (1969). Other sulphide minerals, such as pyrite and chalcopyrite, are present. Sphalerite could not be detected by microscopic examination.

With the aid of X-ray fluorescence, zinc has been detected in two of the faustite and turquoise aggregates. A further element, iron, has also been found. It appears as iron oxide inter-

---

*The chemical formula is, according to Erd *et al.* (1953) as follows: $(Zn_{0.8}Cu_{0.2})Al_6(OH)_8(PO_4)_4\ 5H_2O$; according to Strunz it is as follows: $ZnAl_6(OH)_2(PO_4)_4\ 5H_2O$.

stratified with turquoise in veined matrices as an impurity. A number of other metallic ions have also been detected through X-ray fluorescence examination, as indicated in *Table 1*. Their portions, however, may be well under 1%. The majority of these metallic ions is indicated in the paper of Khorassani *et al.* (1976).

The weathered samples have a light blue, and at times, apple-green color. Most of them are nodular, with cauliflower-like aggregates and are partially veined on the surface.

Secondary minerals worth mentioning are: chrysocolla, iron oxide (iron glance), opal, dioptase, calcareous spar, and malachite. Small quantities of chalcanthite have also been found. This fact is also mentioned by Bariand (1963). Furthermore, small amounts of secondary radioactive uranium minerals (autunite) have been found.

References

Bogdanowitsch, K. 1889. Über Türkislager bei Nischapur in Persien. Verh. Russ. Min. Ges. XXIII Protoc. d. Sitz. 364-365, ref. *N. Jb. Min.*, Bd. 2, 18-19, 1889, Stuttgart.

Bariand, P. 1963. Contribution a' la Mineralogie de l'Iran, *Bull. Soc. Franc. Miner. Crist.*, LXXXVI, 17-64, Paris.

Bazin, O. & Hübner, H. 1969. Copper deposits in Iran. *G.S.I.* Rep. No. 13, 95-97, Tehran.

Diakonov, M.M. 1957. *History of ancient Persia.* Moscow (Russian).

Erd, R.C., Foster, M.D. & Procter, P.D. 1953. Faustite, a new Mineral, the zinc analogue of turquoise, *Amer. Min.* **38**, 964-972, Wisconsin.

Griesbach, C.L. 1886. Afghan and Persian Field notes. *R. Geol. Survey of India,* Vol. 19, pt. 1, 48-65, Calcutta.

Griesbach, C.L. 1887. A geological sketch Map of Afghanistan and North-Eastern Khorassan. R. Geol. Survey of India, Vol. 20, 93-103, Calcutta.

Helmbacker, R. 1898. Die nutzbaren Lagerstätten Persiens. Ref. from Krusch, *Engin. Min. J.-Z.F. Prakt. Geol.* 430-432 Leipzig.

Hinze, C. 1933. *"Türkis" Handbuch der Mineralchemie,* Bd. 4, Abt. 2, Tl. 2, 941-950, Berlin.

Houtum-Schindler, A. 1881. Neue Angaben uber die Mineralreichtümer Persiens und Notizen uber die Gegend westlich von Zandjan. *Jb. K.K. Geol. Reichanst.* Bd. 31, H. 2, 169-190, Wien.

Houtum-Schindler, A. 1886. Die Gegend zwischen Sabzwar und Mesched in Persien. *Jb. K.K. Geol. Reichanst.* Bd. 36, H, 2 U. 3, 303-314, Wien.

Jung, H. 1932, Über Türkis, *Chemie der Erde,* Vol. 7, 77-94, Jena.

Khanikov, N. 1861. *Memoire sur la partie meridonal de l'Asie Centrale,* 234 p. Paris.

Khorassani, A. & Abedini, M. 1976. A new study of turquoise from *Iran. Min. Mag.*, Vol. 40, 640-642. London.

Manutchehr-Danai, M. 1976. Zur Geologie und Mineralogie der Türkislagerstätte Baghu (Nord-Iran), *Z Dt. Gemmol. Ges.*, Vol. 25, H. 1, 15-22, Idar-Oberstein.

Marco Polo 1295. *Die Reisen des Venezianers Marco Polo im 13. Jahrhundert,* bearbeitet von Hans Lemke, 543 pp. 1907 Hamburg.

Pogue, J.E. 1915. The turquoise. *Mem. Nat. Acad. Sci.*, Vol. 12, Pt. 2, third Memoir, 162 pp. Washington.

Stahl, A.F. 1911. Persien. *Handbuch der Reg. Geol.*, Tl. 6, H. 8, 46 pp. Heidelberg.

Strunz, H. 1970. *Mineralogische Tabellen.* 621 pp. Leipzig.

Tavernier, J.B. 1678. *Voyge en turquie en Perse et aux Indes* – edition entierement refondue et corrigee, par Breton, Vol. 1, 421, Vol. 2, 374, Amsterdam.

Tietze, E. 1879. Die Mineralreichtümer Persiens. *Jb. K. K. Geol. Reichanst.*, Bd. 29, H. 4, 565-658, Wein.

Tietze, E. 1884. Das Vorkommen der Türkise bei Nischapur in Persien (Report). *Verh. d. K.K. Geol. Reichanst.*, N[illegible] 6, 93-99, Wien.

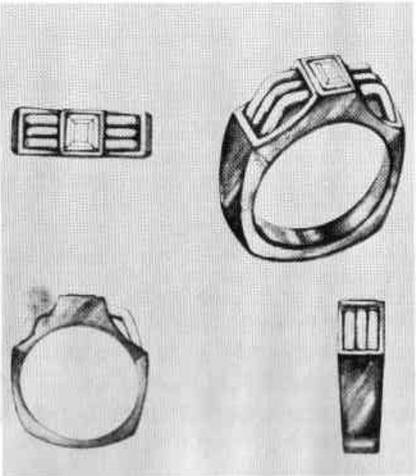
Geological Map of Iran, N. I. O. C. 1957, Tehran 1 : 2,500,000.

Tectonic Map of Iran. G.S.I. 1971, Tehran, 1 : 2,500,000.

1977 Schuetz Design Contest Winner

Miss Yoko Tanaka, an employee of Miwa Company, Tokyo, Japan, has been named the winner of the 1977 George A. Schuetz Memorial Fund Design Contest. Her outstanding prize-winning design and exceptional rendering is for a man's ring featuring diamonds, platinum and yellow gold. She has been awarded a $300 scholarship for any jewelry related training at an institution of her choice.

The yearly contest was established in the memory of George A. Schuetz former president of Larter & Sons, Newark, New Jersey. The contest is administered by the Gemological Institute of America. Anyone may enter. Entries are limited to designs for men's jewelry. All entries are judged on the basis of beauty, originality of design, feasibility of wear, manufacturability and the effective use of metal and stones for men's jewelry. Designs must be original and cannot have been previously exhibited publicly or offered for sale. Entries are made in the form of renderings or wax models. Photographs or actual pieces are not accepted.



Thirty entries were submitted for the 1977 contest. Members of this year's panel of judges were Robert Ahrens, jewelry designer for Van Cleef & Arpels of California, Inc.; Angel Castelo, jewelry designer and manufacturer, Beverly Hills, California; and D. Vincent Manson, Ph.D., Research scientist at the Gemological Institute of America, Santa Monica, California.

In announcing their decision, the award committee congratulated Miss Tanaka and expressed their sincere appreciation to the other contestants for submitting entries.

Information about the 1978 Schuetz Design Contest is available in the fall. Please write GIA, 1660 Stewart Street, P.O. Box 2110, Santa Monica, California 90406.