



The presence of treated topaz in the Gem Industry has become de rigeur. However, as enhancement technology improves, so does the ingenuity of the enhancer and gemologists must develop better strategies for detecting enhanced stones. Gem Quality Institute's Richard Hughes and AGA President Thom Underwood analyze surface-enhanced topaz and methods for its detection.

Surface-enhanced Topaz

by Richard W. Hughes & Thom Underwood

At the 1998 Tucson Gem Fair, a new type of enhanced topaz made its appearance (Johnson et al., 1998; Hodgkinson, 1998). This new topaz has been described by one producer, Richard Pollak of United Radiant Applications in Del Mar, CA (where he produces blue to greenish-blue treated topaz) as a surface-diffusion enhancement, where the color is confined to a thin layer at and just below the surface.

In addition to Pollak, Charles Lawrence of CL Laboratories in Encinitas, CA is producing similar material, but in a wider range of colors, including an emerald green.

Why surface-enhanced topaz?

With the plethora of low-priced, irradiated/heated blue topaz in the market, the first question that comes to mind is: "Why does the world need a new blue topaz treatment?" We put this question to Richard Pollak and Charles Lawrence, who explained the advantages of the surface-treatment process. Unlike most irradiated topaz, the new treatments result in no residual radioactivity—thus requiring no costly cooling down period while the stones decay to safe levels. Secondly, the new process allows for colors other than blue. As for the disadvantage of losing color if a stone is

chipped or requires recutting, the low price of this material means that it is a simple matter to replace the entire stone.

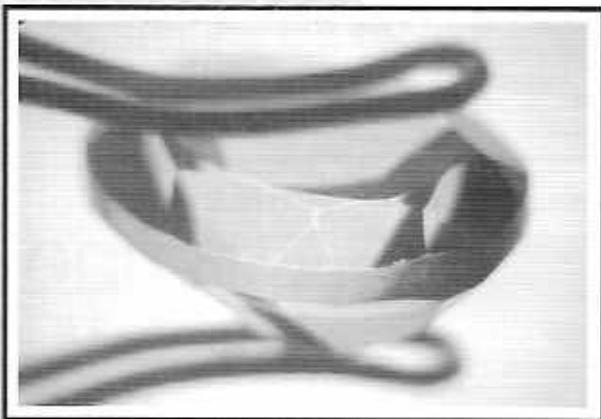
The Kirkendall effect

One of the classic experiments in defining diffusion was performed by A. Kirkendall (Shewmon, 1989). In this, a bar of 70—30 brass was wound with fine molybdenum wire (molybdenum is insoluble in copper and brass) and then plated with about 0.1 in. of copper. This couple was then given a series of successive anneals. After each anneal, a piece was cut from the bar and polished. This revealed (rather than the copper diffusing into the brass) more diffusion of zinc from the brass outward into the copper. This demonstrated that the diffusion rate of zinc into copper was far greater than that of copper into zinc.

Now, on to the topaz that is the subject of this article.

Microscopic examination shows the color of this material confined to a layer at and just beneath the surface. According to the manufacturers, this color layer results from heating in a cobalt-rich powder. This layer is so thin that the question has arisen whether this represents a surface coating or a surface-diffusion process. The Kirkendall effect suggests that this may be a moot point. When the topaz is packed in the coloring agent and heated up, an impure surface layer forms. Rather than being a mere incident of the

Continued on page 4—



A lack of coloration at the facet junctions

ABOUT THE AUTHORS

Richard Hughes is an expert on corundum, author of the critically acclaimed Ruby & Sapphire and self-professed Devil's Advocate. Thom Underwood is an ASA Master Gemologist Appraiser, a certified gem lab and cares for several terrapins in his backyard.

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Book Appraisals

The Complete Handbook for Gemstone Weight Estimation

By Charles Carmona
Gemania Publishing Company
550 South Hill St., Suite 1188
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Could life get any better for those of us who calculate the weight of gemstones for a living? First we get paid to handle enchanting baubles and call it our profession; and now we have Charlie Carmona's *Complete Handbook for Gemstone Weight Estimation* as the ultimate source for formulas and charts to assist us in weight estimation. This handbook is a complete resource!

When I first talked with Charlie last year about his book, I was thinking about how nice it was going to be to have a pamphlet that compiled all the weight estimation work he had done over the past two decades. Charlie has always been the one to call when you had one of those weird shaped gemstones in front of you with no idea how to figure out its weight.

When the book arrived, I was first drawn in by the professional quality of the publication from the binding to the cover. Simple things please simple minds! Well, next I got a grip on myself and took a look inside. Whew! Charlie has covered all the basic shapes and some I couldn't even find in my dreams.

The introduction is concise and to the point. It has simple to learn techniques for using the handbook, including use of the tables, weight correction factors and even methods for visualizing shape changes (slight shape differences between the charts and your gemstone) and how they affect your weight estimation procedures. In order to keep the size of the handbook reasonable, gemstones are combined into eight specific gravity groupings with corresponding charts that reflect these eight groupings in columns. Diamonds,

however, have their very own section of formulas and charts.

The charts are laid out in an easy-to-use manner with indexed tabs along the outer edge of the page to expedite finding the chart you need. The pages themselves are organized into two page layouts with the charts on the left; the layout displays a list of the significant gemstones; the appropriate formula for the respective shapes; and indications of adjustment factors. This well-thought-out layout provides the researcher with all the needed facts at a glance. Charlie thought of everything.

The only shortcoming I could find in the book was the disclaimer. You know — the same sort of statement that you probably have in your appraisal (OK so you call it a statement of limiting conditions). Why was this disappointing? Well Charlie's disclaimer insists that I am still responsible for my own estimated weight conclusions. Gee — I was hoping I could eliminate one more liability in my work.

Oh well, I guess I must continue to stay alert when estimating gemstone weights, however, thanks to *The Complete Handbook for Gemstone Weight Estimation* I expect to improve my accuracy this coming year.

— Thom Underwood

BULLETINS

There will be an **AGA Membership meeting** immediately following the Symposium (around 5:00) in Tucson on Thursday, February 4, 1999.

There will be an **AGA Board meeting** at the Tucson Convention Center in the Agate Room from 9:00 -10:00 a.m. on Friday, February 5, 1999.

Cameos Old & New 2nd Edition

By Anna Miller, G.G.

Gemstone Press, Sunset Farm Offices
Route 4, P.O. Box 237
Woodstock, VT 05091.



Anna Miller's book, *Cameos Old & New 2nd Edition*, has blended the scientific study of the cameo with the aesthetic and symbolical view. Perusing her writing takes the reader back in history to the Renaissance, widely regarded as the rebirth of western art and learning following Europe's Dark Ages. Just as that period in history demonstrated a balance between the aesthetic and the academic, in *Cameos*, Miller resists the impulse to focus exclusively on the art or science of the cameo. Instead she offers the reader a balance between the aesthetic and often mystical symbolism associated with cameo carvings, as well as the nuts and bolts of the techniques behind those carvings and ways of determining their material value.

Miller's text is a great update and revision of her book on the glyptic art of carving cameos. It is also a lesson in art appreciation. Not only does the book cover the 2500 year history of cameos (including their materials, carving themes and styles); it identifies and interprets much of the symbolism depicted in cameos from the ancient Greco-Roman civilization to 20th Century civilization. There are brief descriptions of more than 70 Greco-Roman divinities as well as other mythological figures frequently found on cameos and fine art throughout the western world.

A rather in-depth section of *Cameos* illustrates the evolution of carving, including a detailed account on identifying the

ultrasonic method. It even references hair styles and facial features characteristic to ancient and contemporary cameo carving as a means to help date a particular cameo. Although this method is only indicative, it is rather interesting and educational.

Miller covers even more topics that relate to cameos. These topics include collecting cameos, existing historical cameo collections of note and points of cameo artistry. A particularly notable section contained useful price information including many examples of cameo auction prices from the mid-1990s, dealer prices and prices to use as references when buying a newly carved cameo from a retail jeweler. On the subject of pricing and value, there is a brief statement regarding cameo appraisal and a chart tracking cameos as an investment over the last 20 years, a useful reference for collectors.

Appraisers will be interested in the list of famous cameo carvers and their signatures. Here, the author provides brief information on more than 30 important cameo carvers from the 16th to the 19th Centuries.

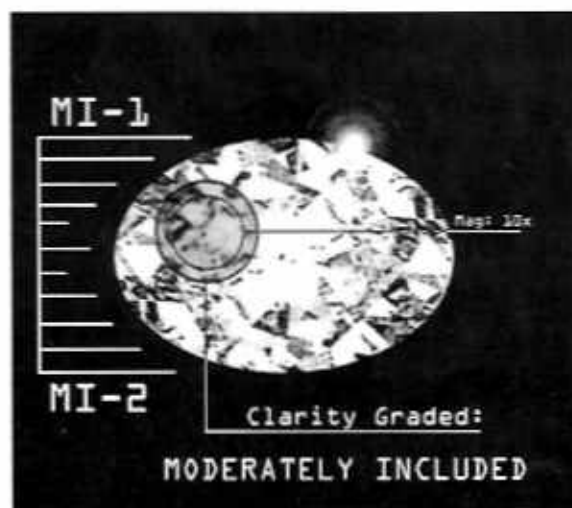
All in all, I found that *Cameos Old & New* is a well-written and easy read. The numerous photographs (B/W and color) show the styles and quality of the carvings but also provide good information on cameo frames and mountings. There is also a glossary of glyptic art and jewelry terms. Not only will I add this book to my home library, but I will most likely include it with my traveling, "working" library as a good reference of art themes and symbolism. ■

— Craig Lynch

GQI Chicago Makes the Grade

As reported last issue, AGA member Tom Tashey has opened a new Gem Quality Institute in Chicago. However, Tashey, the founder of the original GQI in Los Angeles, has wasted no time in making the new lab's presence felt in the Gem Industry.

GQI-Chicago has instituted two new grades to the clarity scale — MI-1 and MI-2. These grades (denoting moderate inclusions) are applied to stones with clarity between the GIA's SI₁ and I₁ grades. Further, the MI grades make the SI₁ grade (instituted by GQI Los Angeles a few years ago) unnecessary. ■



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Rebecca Donald
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Surface-enhanced Topaz

Continued from page 1—

cobalt moving into the topaz, it is possible that the topaz constituent atoms diffuse into the coloring agent, or perhaps a bit of both. Thus it appears likely that the color layer results, at least in part, from diffusion.

Johnson et al. (1998) reported that for the United Radiant Applications material, the color layer could not be scratched away even with a piece of quartz (Mohs' hardness = 7). Only another piece of topaz could scratch the layer. This further suggests the process involves diffusion.

Cobalt—the culprit

At the request of CL Laboratories, William C. Trogler, professor of chemistry and biochemistry at University of California at San Diego, performed research on the cause of color in high heat chemical-treated topaz.

In Trogler's preliminary conclusions he writes:

An explanation (for cause of color) based purely on impurities does not seem reasonable, since the green stones can be turned blue on heating. The most likely explanation is that the green color represents an unstable lattice phase of topaz (probably only on the surface) where the cobalt ions occupy unfavorable lattice sites. On heating the lattice equilibrates, the cobalt ions occupy normal sites and the normal blue color is obtained. The unusual lattice could either be one significantly different from topaz (perhaps due to the fluorine loss from the surface) or



Bag and trays of treated topaz

else represent differing occupation of cobalt ions in tetrahedral and octahedral lattice sites.

The color is most likely caused by cobalt in the lattice structure. The EDAX surface composition for comparison with (unenanced) topaz lattice shows that the wt% composition of cobalt is huge and suggests a heavily doped surface layer (Trogler, March 1998).

Trogler goes on to state:

The ratios of the wt% values of the nonoxygen element is probably most meaningful. Pure topaz has an Al:Si ratio of 1.92 whereas the green stones (treated topaz) have a ratio of 1.41. This suggests extensive substitution of Al by cobalt in the surface layer. The weight percentage of the silicon suggests it is perturbed the least and so the ratios relative to silicon are most useful.

Mullite formation and the RI shift

Further, Trogler suggests:

The substitution in of significant

sodium and calcium is also suggestive of a surface coating whose composition is so far perturbed from that of topaz that there may be a different mineral form on the surface layer. In this context, it is noteworthy that the absorption spectra suggest a far heavier doping of the surface in the green stones than in the blue ones.

In experiments performed by Day et al. (1995), it was found that "Topaz $[Al_2SiO_5(F,OH)_2]$ decomposes on heating above $\sim 1100^\circ C$ into mullite (nominally $3Al_2O_3 \cdot 2SiO_2$), but the composition may involve a liquid phase, a vapor phase or both. Hampar and Zussman [Hampar et al., 1984] proposed a multi-stage reaction mechanism to explain the thermal decomposition of single topaz to produce minor glass (liquid), cristobalite, and even corundum, as well as mullite." (Day et al., 1995).

Trogler concurs:

There are also some interesting phase changes in topaz that yield mullite and glassy silica at $1150^\circ C$. (Day et al., 1995). The product is primarily mullite ($3Al_2O_3 \cdot 2SiO_2$) which occurs by loss of HF due to the reaction of water vapor. The

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oven cement may introduce water vapor that could accelerate fluoride loss. Narrow rinds of glassy silica rich in K_2O and Na_2O and with nearly no alumina present also was formed. The loss of fluoride in the green topaz surface layer suggests that some new mineral phase, whose index of refraction differs considerably from the underlying topaz, may be bound to the topaz surface. The large decrease in alumina and fluoride, and large increase in cobalt and sodium would be expected to significantly influence the structure. In particular, the incorporation of sodium is more suggestive of a glass than a well-defined lattice.

The green color — and a durability issue worth noting

As to the effect of nickel, Trogler has these comments:

According to the EDAX the Co:Ni ratio is about 7:1, which is an appreciable amount of nickel. Under certain

circumstances, nickel ion gives a broad absorption in the ultraviolet that tails into the blue spectral region (absorbs blue) and gives a yellow color. That may account for the broad absorption from 440 nm (violet-blue) to 300 nm in the green topaz. This absorption/coloration is very sensitive to the lattice according to Rossman (1981).

Charles Lawrence has reported that his green surface-enhanced topaz will lose its color in a pickling solution and leave a lightly frosted surface. This is not true of his blue stones. Pollak states that his stones do not lose color in the pickling solution, but this is probably because his stones are not a true green.

This differing reaction to an acid bath might be explained by referring to Trogler (1998), who suggests that in the green variety of surface-enhanced topaz, cobalt ions occupy "unfavorable" lattice sites that constitute an "unstable lattice phase of topaz (probably only on the surface)." We hypothesize that the pickling solution may provide the correct environment for a chemical reaction which causes the leaching of colorant(s) from the surface layer of the topaz and hence a loss of color.

Continued on page 7 —

TABLE 1. Properties of the new color-enhanced topaz

Property	Description — United Radiance Applications product (5 stones)	Description — CL Laboratories product (9 stones)
Color	Blue to greenish blue Munsell Hue = 7.5B—10B; Tone = 6; Saturation = 12—14	Munsell Hue = 10B; Tone = 6; Saturation = 12 Green: Munsell Hue = 3.5—10G; Tone = 5—6; Sat. = 13—15
Color distribution	Even to the naked eye; patchy surface coloration under magnification	Even to the naked eye; patchy surface coloration under magnification, often with green spots; white facet junctions /chips against a white diffusion filter
Luster	Resinous subadamantine luster on polished surfaces	Resinous subadamantine luster on polished surfaces
Pleochroism	None to faint; generally two different shades of blue	None to faint
Transparency	Transparent	Transparent
Optic character	Doubly refractive, biaxial, positive Doubly	
Refractive index	Table facet: $n = 1.608—1.610$; $n = 1.610—1.614$; $n = 1.618—1.620$ Pavilion facet: Anomalous readings; often above 1.81	Anomalous readings; generally above 1.81 Birefringence undeterminable
Specific gravity	3.56—3.57	3.50—3.63
UV fluorescence	LW: Inert SW: Inert to faint yellowish green LW: Very faint red flash	LW: Very faint red flash SW: Very faint red flash
Visible spectrum	Cobalt spectrum: bands at approx. 560, 590, 640 nm.	Cobalt spectrum: bands at approx. 560, 590, 640 nm.; strongest in blue stones, weaker in green stones
Magnification	Parallel particle strings & clouds Crystals or negative crystals with tension disks	Parallel particle strings & clouds Crystals or negative crystals with tension disks
Chelsea filter	Red	Green stones: Pinkish purple Blue stones: Red
Price	Wholesale: \$3/ct.	Wholesale: \$16—35/ct.

PEARLS

AUSTRALIAN GEMOLOGIST
Terry Coldham has just sent us the following news on the Cook Islands pearl fisheries. Please note the request for information that follows his account:

I have just returned from Penryhn Island (local name: Tongareva) and what a fantastic place it is. It's an atoll with a very large and deep enclosed lagoon in which there are some pearl farms for black pearls. This is the second island to grow pearls in the Cook Islands and they have only been going for about five years. Their farms are only allowed to be owned by Penryhn islanders and are very, very strictly controlled as far as over-farming and pollution are concerned. The Island's population is only about 400 people and they have about 20,000 oysters, which compared to other areas is a very small amount.

I had the opportunity to see and photograph the seeding and re-seeding operations. My friends there allowed me to see everything, including a step-by-step demonstration of re-seeding using an opened oyster so I could see and photograph each step.

Their pearls seem to be especially good and lustrous; we harvested 18 oysters that had been re-seeded after a first har-

vest. We got 16 pearls and one keshi. Of the 16, 10 were very good in terms of shape, lack of blemishes and colour and ranged in size from 11mm to 14mm. They also produce black and silver mabe pearls but, due to their lack of experience in preparation, these look more like blisters than real mabes. I spent a few days teaching them how to properly prepare them. Their problem was not that the mabe produced by the shell was not of good shape, but rather they just didn't know how they should be prepared. We ended up with very nice round-, drop- and oval-shaped goods with a nice polished mother-of-pearl back.

Apart from the people and their wonderful community, I found the most interesting thing was the local, golden "Pipi" pearl. I believe this oyster is widespread throughout the South Pacific, including Tahiti, but apparently pearl-bearing oysters are most prevalent on Penryhn. Anyway, we spent a day collecting these small oysters off a few coral heads in the lagoon. They are in about two-to-four feet of water and occur in large numbers. We then proceeded to open them, looking for natural pearls. We did very well, finding about 12 in some 600 oysters. They ranged from white to golden and have a beautiful luster. Most were well shaped and ranged in size from 2mm to 5mm. One large one of about 8mm was attached to the shell, the amazing thing being that the shell is only about 20mm across and it's hard to believe the oyster could live with such a relatively large object inside it. I was made a gift of all the pearls we found, as this is the tradition of the island. So I have the photos, the pearls and their shells and intend to write an article about them.

Actually **I want to find anyone who has any knowledge of the Pipi Pearl oysters (*Pinctada maculata*).** I would appreciate being contacted by anyone who has had experience with the Papis or knows of anything published about them. Address: 6th Floor 45 Market Street, Sydney Australia 2000. GPO Box 4524 Sydney Australia 2001. Email: gjap@ozemail.com.au.



Showing two loose pearls, on either side of the shell. Although the pearls appear to be sitting on the flesh of the oyster they are in fact enclosed in a very fine transparent membrane that is attached to the nacre producing tissue (the white and black spotted band of material running parallel to the lip of the oyster on both shells).



Summit in the Sunshine

The International Gemological Symposium will be held in San Diego this summer. Dubbed as "the world summit on diamonds, colored stones and pearls, jewelry and business," the International Gemological Symposium boasts a full roster of heavy hitters, ranging from the GIA's appointed president, William E. Boyajian to business expert, Peter Ueberroth.

The Symposium promises to provide a full itinerary of social events, including a special diamond exhibition in San Diego's Natural History Museum and a tour of the highly secured Gemological Institute of America.

For people interested in more spontaneous activity, there is the War Room, "where opposing views find voice in heated debate." If you've got strong opinions and answers to industry issues like: disclosure, branding and diamond cut, take them to this open forum.

The Symposium takes place from June 21-24, 1999. For information, call 1-800-421-7250 ext. 4406 or go to the website at www.gia.edu.

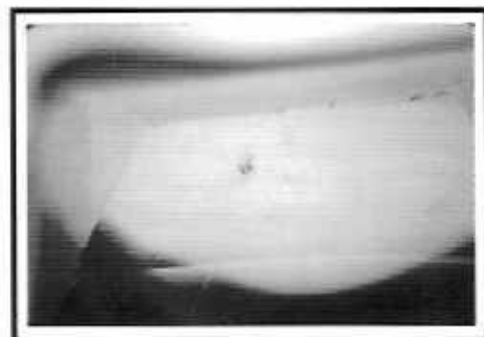
Properties

By far, the most important identifying feature is the color distribution at the surface. Many stones displayed surface chips where the colorless nature of the interior topaz was revealed. Placing a white glass or plastic diffusion filter over the well of the microscope reveals a spotty surface coloration, with many stones displaying a lack of color at the facet junctions.

To determine the thickness of the color layer, GGI's Martin Guptill sectioned cut stones. This revealed a color layer so thin that it could not be measured with standard gemological equipment.

House of mirrors — Crazy RI readings

Perhaps the most unusual characteristic of surface-enhanced topaz is the anomalous refractive index (RI) readings. When tested on the standard gemological refractometer, enhanced topaz displays RI's ranging from normal (comparable to unenhanced topaz) to diffused (a broad vague band versus a distinct shadow edge) to none at all (above the 1.81 limit of a normal refractometer). It appears that the topaz surface might indeed be transformed into mullite, glass and other substances. According to Phillips et al. (1981), mullite has a refractive index in the range of 1.634—1.690 (n_p — n_s 0.010—0.024), while glass can be higher or lower. Neither would explain



(Above)
Loaded
crucibles
stacked in
the oven
prior to
treatment.

A deeper color "center."

Continued on page 8 —

**READY
TO RUN
WITH THE
BIG
GUYS?**



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For an information packet on the CGL Program, call Jim Naughtner at (518) 438-8872, or email the AGA headquarters at thomu@earthlink.net

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— Continued from page 7

the wide range of RI readings. More likely, the high concentration of cobalt near the surface is responsible for the high RI readings, while variations in the depth of post-enhancement polishing would account for the vague and varying but lower RI readings. Indeed, our testing showed a single stone can produce a variety of RI readings depending upon which facet is tested.

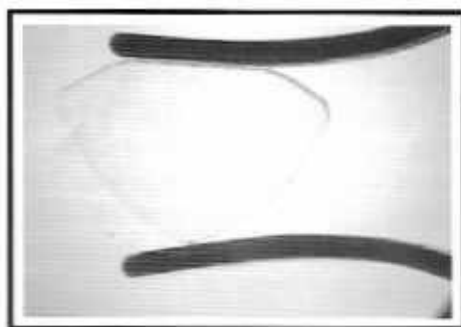
It is interesting to note that RI readings for the Radiant Technologies product were unremarkable on the table facet, but anomalous readings (including readings above 1.81) were encountered on pavilion facets. Those for the CL Laboratories product were anomalous for both the table and other facets, including many above 1.81. This suggests that extra polish has been applied to the table facet. When asked about this, Richard Pollak told one of the authors (RWH) that he does not sell material himself, but only processes material for others and suggested that the heavy polishing of the table facet was performed by one of his customers (pers. comm., 7 Dec., 1998). His customer, Kenneth Moghadan, confirmed this (pers. comm., 11 Dec., 1998).

Conclusion

With gemstone enhancements, status as a fact of life in today's colored stone market, we can expect to see more of such novel treatments in the future. Fortunately, in the case of the surface-enhanced topaz, identification is rather simple. ■

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A view of a sectioned treated topaz — cut by Martin Guptill (GQI)

Irregular surface coloration



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Acknowledgments

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All photographs provided by Richard Hughes (GQI).

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