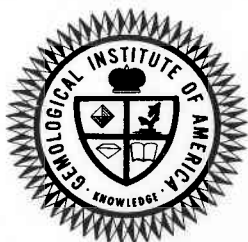


# Gems & Gemology

GIA



WINTER 1973-1974



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**GEMS & GEMOLOGY**

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# Gems & Gemology

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# Natural and Synthetic Turquoise

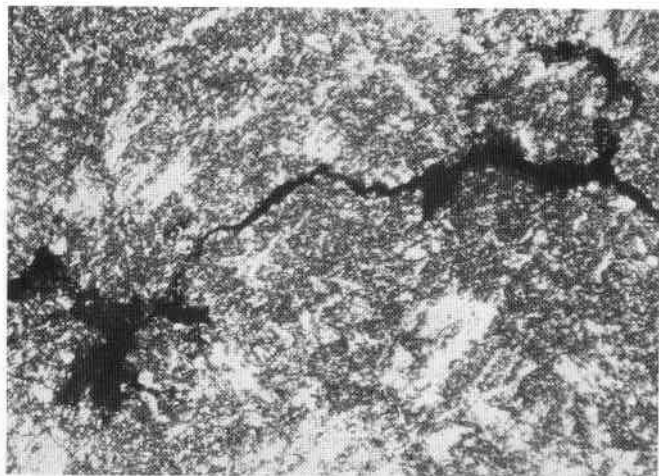
By PROF. DR. W. F. EPPLER

Turquoise is one of the "oldest" known gemstones. It was already known about 4000 B.C. near the southwest coast of the Sinai Peninsula in the area of Djebel Serbâl (M. Bauer, 1909) and since that time it has not lost its popularity and appreciation.

As it is generally known, turquoise is opaque and has a very fine-grained texture and the well-known greenish-

blue to bluish-green "turquoise color," which originates from its copper content of the hydrous copper-aluminum-hydroxyl-phosphate. The fine turquoise grains are partly rounded and partly fibrous and arranged completely without any orientation. This is shown in *Figures 1 and 2*. Both pictures are taken with the Polaroid plates crossed; therefore, the nume-

*Figure 1. Turquoise of unknown origin showing small veins and spots of limonite. Thin section, crossed Polaroids, 126x.*

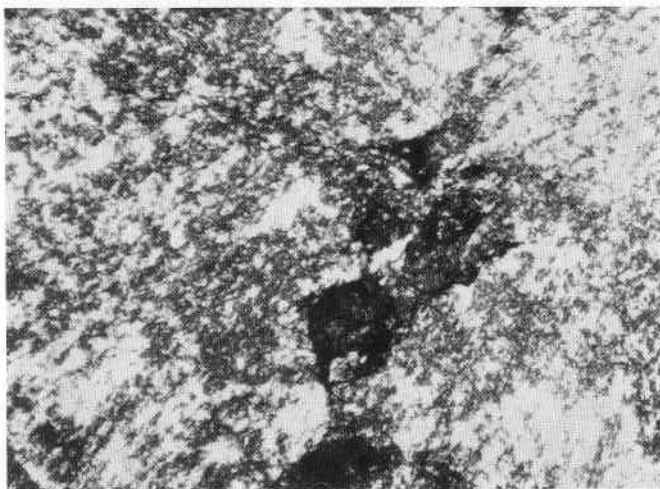


rous little dark spots also consist of doubly refractive turquoise crystals, which, however, are at extinction position. The larger darker spots in *Figure 1* are brown limonite (Greek "leimon" = meadows, or brown iron ore, an iron hydroxide). *Figure 2* shows remnants of trachyte (Greek "Trachytes" = roughness), a geologically young eruptive rock which in some deposits is the host rock of turquoise.

A peculiar turquoise is found in Israel close to Eilat in the location formerly known as the "Copper Mines of King Solomon" dating from 1,000 B.C. It is found in small veins and in the cracks of a gray silicified sandstone. Sometimes it is accompanied by tenorite, a monoclinic copper oxide (CuO), which forms rounded black spots and areas. Turquoise very often shows an intergrowth with a malachite-like pseudo-malachite, a hydrous copper phosphate  $(\text{Cu}_5[(\text{OH})_2|\text{PO}_4]_2$  or  $5 \text{CuO} \cdot \text{P}_2\text{O}_5 \cdot 2\text{H}_2\text{O}$ , which crystal-

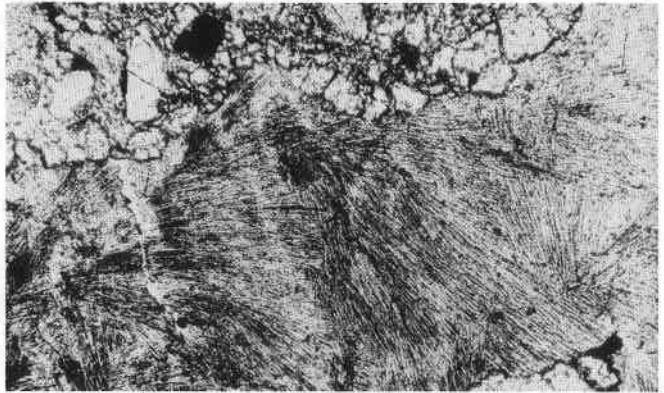
lizes in the monoclinic system. This green mineral forms long and short fibers, which are irregularly oriented in groups (*Figure 3*). In the upper part of the picture, the almost quadrilateral-shaped grains of sandstone are seen, which are combined with small and very small grains of quartz. The few black spots consist of an opaque ore. The larger part of the picture consists of the fibrous pseudo-malachite which runs over into the turquoise at the lower part of the picture. This impressive intergrowth is known in the trade as Eilat-stone.

The production of synthetic turquoise was attempted for the first time by M. K. Hoffman, (1927, *Fortschritte der Mineralogie*, 12, 45). He reports: "Solid, finely ground aluminum sulfate, aluminum hydroxide and cupri-sulfate is heated with di-sodium phosphate and the refined sodium-sulfates are precipitated and washed out so the turquoise mass is then formed of



*Figure 2. Turquoise of unknown origin showing small residue of trachyte (dark). Thin section, crossed Polaroids, 126x.*

*Figure 3. Turquoise from Eilat, Israel, together with pseudo-malachite. Thin section, 65x.*



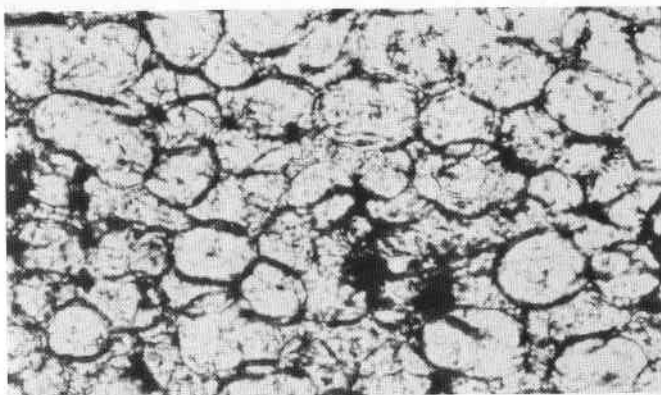
malachite ( $\frac{1}{2}$  mol), aluminum oxide (6 mol) and concentrated phosphoric acid (2 mol) when heated a little above  $100^{\circ}\text{C}$ . The malachite-aluminum-hydroxide powder has to be ground and finely mixed, preferably in a colloid mill. The turquoise is hydraulically pressed in molds, then cut and polished (filed for patent D.R.P.). Hardness, S.G., color and chemical analysis prove the successful synthesis of turquoise."

Later, around 1970, the firm of P. Gilson, France, marketed a synthetic turquoise, which shows a good turquoise color, although it appears to be somewhat "milky." Moreover, it does not show any matrix. The S.G. varies a little bit from 2.72 to 2.74 as mentioned by R. Webster, 1973. Thus, it is within the range of natural turquoise, which shows 2.60 (USA) and 2.85 (Persia). On the refractometer it shows a uniform R.I. of 1.60 which is definitely lower than the R.I. of natural turquoise (1.62).

Under a 10X loupe the synthetic turquoise shows very fine grains. It also shows a very regular and fine

pattern not seen in any natural turquoise. At higher magnifications under the microscope the pattern that appears consists of slightly deformed spheres, the average diameters of which are  $0.032 \times 0.045$  mm (Figure 4). In polarized light they show the "extinction cross in spherulites" and thus consist of fine, doubly refractive fibers, which undoubtedly are synthetic turquoise. The black fringe around the spheres (in the picture, the black fringe of the discs = diametrical spherical sections) consists of a still unknown singly refractive substance which might be a gel-like aluminum hydroxide. It acts like a cement that holds the spheres together and is probably responsible for the somewhat lower S.G. The production of this synthetic turquoise is probably similar or even the same as described by Hoffmann over 40 years ago. Also, the fact that compression is used can be seen in the visible deformation of the spheres.

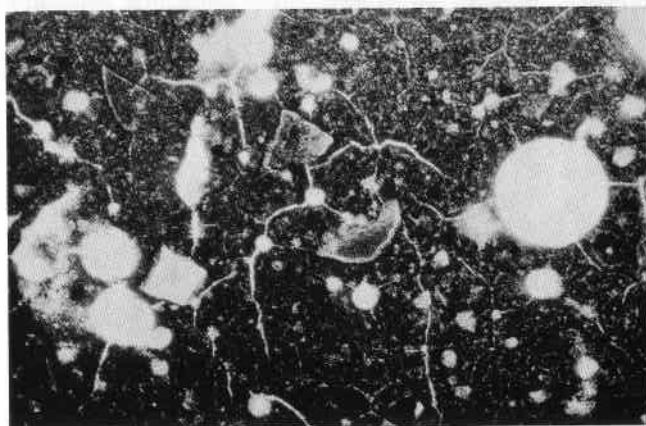
Turquoise might be confused with similar-looking minerals which can, however, be identified by their dif-



*Figure 4. Synthetic turquoise by Gilson. Thin section, 246x.*

ferent properties. The imitations and fakes are numerous, dating back to the early times of Egypt. Some of them have names of their own, like "Wiener turquoise," seen around the turn of the century, and "neolith" or "neoturquoise," used about 15 years ago. For example, in recent years there is a fake produced from aluminum hydroxide and copper sulfate which undoubtedly was held together by heating and compression. The hardness is like turquoise (almost 6) but the color is much too blue, not seen in any natural turquoise. The S.G. is 2.2 and

is a sure means of identification. The thin section (*Figure 5*) shows that in a gray-greenish groundmass (black in the photograph) opaque and sometimes translucent particles of a solid substance are embedded and that a relatively larger number of gas bubbles are present. They certainly cause the low S.G. Noteworthy, also, are the many cracks which together with the described structure and the "unreal" looking color without a doubt differentiate natural from synthetic turquoise.



*Figure 5. Turquoise imitation consisting of aluminum hydroxide and copper sulfate. Thin section, 65x.*

# Developments and Highlights at **GIA**'s Lab in New York

By ROBERT CROWNINGSHIELD

## Diamonds, Diamonds

Although we do not usually examine heavily flawed diamonds in New York, we do see enough diamonds with laser drill holes to realize that the practice has become an established and accepted part of the trade. Until now the record number of holes in a single diamond — a marquise of nearly 5 carats — was five. Some sort of record was reached last week when we examined an 0.97 carat oval stone with 10 drill holes! One hole was remarkable in

that it did not actually reach the object sought but an "off shoot" did, and the inclusion was white (*Figure 1*).

Another diamond with one long laser hole was examined, and the hole was found to have fractured along its length (*Figure 2*) making it look like barbed wire. On a hunch we observed the stone under polarized light. We found that the hole had passed through an area of intense strain which probably accounted for the unexpected fracturing (*Figure 3*).

*Figure 1*

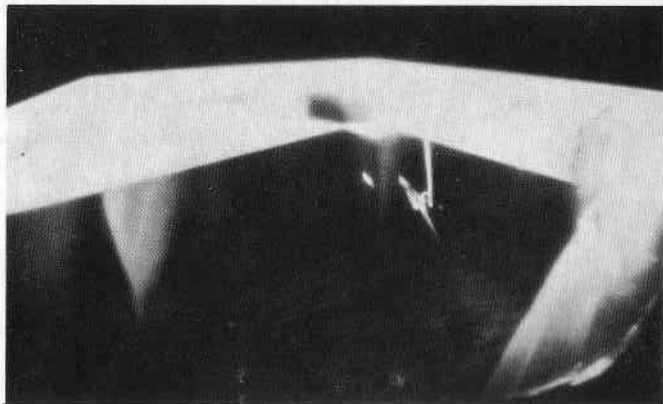






Figure 2



Figure 3

Figure 4 illustrates a lack of knowledge on the part of a jeweler who “proved” that the emerald-cut stone was not a diamond because it was scratched by a diamond. He did not realize that a diamond will scratch another diamond, especially if the testing point is brought against a soft direction, which the table of this stone was.

In Figure 5 we see the “before” situation where two side marquise diamonds are touching the large fancy yellow center diamond. We could almost bet that the center stone will be damaged within a short time after it is sold and worn. It would be a pity since the center stone is almost flawless and weighs well over 20 carats.

Damage to two adjacent diamonds mounted in an elaborate platinum bracelet is seen in Figure 6. The

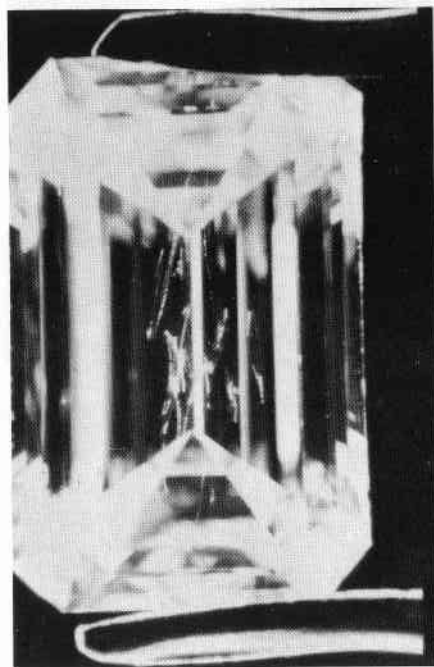
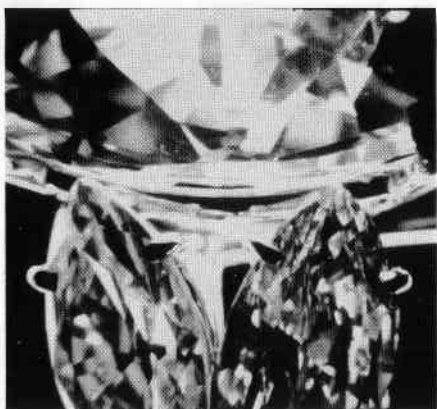
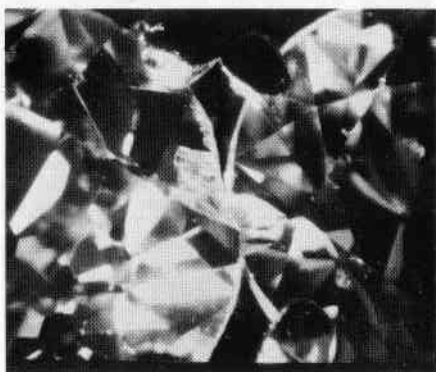


Figure 4



*Figure 5*



*Figure 6*



*Figure 7*



*Figure 8*

damage must have occurred during the setting because the stones are over size for the setting.

Similarly, *Figure 7* shows damage to a marquise diamond mounted in such a way that the tapered baguette side-stone touched the girdle. One especially heavy blow to the ring caused the baguette to move inward with the disastrous result. It would seem that designers should provide a barrier of metal between side diamonds and center stones. This reminded us of one nearly 30-carat flawless and colorless marquise which was damaged on both sides because the baguettes touched the pavilion. It was no simple matter to repair the damage because recutting the center part of a marquise makes an obvious difference in appearance which the owner immediately recognized. More than two carats were lost in returning the stone to flawless condition with an eventual acceptance by the owner. The monetary loss was considerable, to say the least.

In *Figure 8* the emerald in this platinum and diamond ring had suffered damage when during wear one side diamond had "attacked" it.

### A New Opal Doublet

We are indebted to Mr. Michael Costello of the Opal Centre, Sydney, Australia, for bringing to our attention an assembled stone that very closely resembles Queensland boulder opal. In *Figure 9* we see what appears to be an irregular opal on ironstone matrix. In reality it is probably Coober Pedy opal cut with an irregular back which is



*Figure 9*

then finished off with a mastic material consisting of powdered ironstone, some opal and plastic. The back is shown in *Figure 10*. Under ultraviolet the bits of opal fluoresce and bubbles in the plastic (epoxy?) can be seen under magnification. When examined quickly in a setting, these handsome substitutes could pass for natural stones.

### An Unknown Opal

The opal in *Figure 11* had a most unusual appearance — something like



*Figure 10*

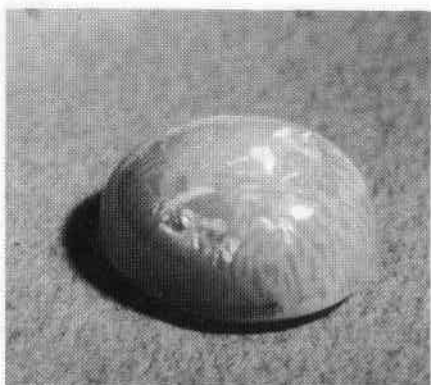


Figure 11

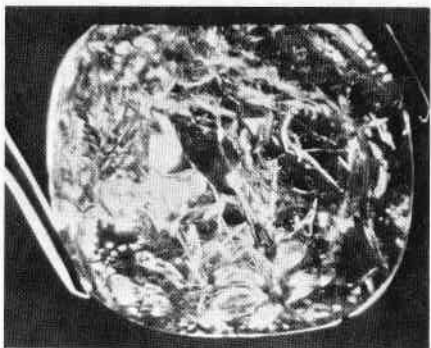


Figure 12

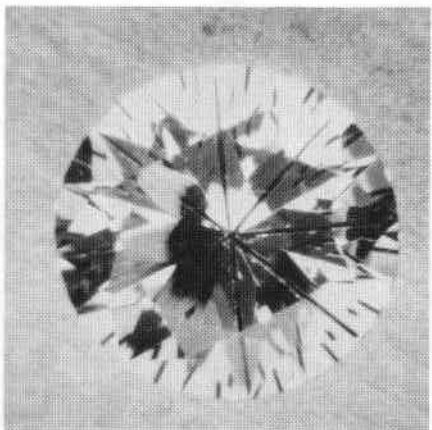


Figure 13

the pattern in the fur of some cats. The color was a variegated brown and the fire became much more pronounced when the stone was moistened. Its low specific gravity (near 2.00) suggests that it may be of Mexican origin.

### Temperature Effects

Rapid temperature change as a cause of damage continually comes to our attention. The need for knowledge about this among jewelers, repairmen and wearers is evident. Perhaps the list of the most heat sensitive stones should be headed by peridot. We are convinced that it should be approached with awe and great respect. One jeweler who sent out a ring containing a peridot larger than 50 carats for sizing was faced with the job of replacing a shattered stone. He was ready to take a flight to Brazil until a staff member suggested that peridot is not mined there. Another stone which frequently comes to our attention after it has been mistreated in respect to temperature change is garnet. Possibly the false double refraction so often noted in these stones is a clue as to why they cannot take a rapid temperature change. In *Figure 12* we see the remains of a nearly 30-carat rhodolite garnet which the owner decided to clean (it was a fine ring then) by boiling it in ammonia water! (Of course, it boiled dry, and naturally she poured cold water into the pan.) Other stones on the heat sensitive list would include tanzanite and the clear quartz stones — to say nothing of cat's-eye apatite.

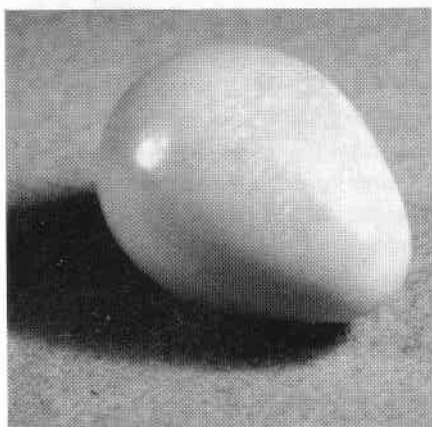


Figure 14



Figure 15

### A Real Reflector

Figure 13 is a photograph of a rock crystal containing a single black tourmaline needle which begins at the culet and extends straight up toward the table. It can be seen in every facet when viewed from the top. We thank the owner, Dr. Kurt Nassau, for allowing us to photograph it. It occurred to us that a blue filled laser hole in the same position in a diamond could make a mighty interesting stone.

### A Real Rarity

Recently we were asked to identify a smooth, egg-shaped, clear yellow "stone" which the owner had secured years ago in the Orient. Its surface appearance and an x-radiograph indicated a conch or other non-nacreous pearl. Back to the library we went to learn that yellow conch pearls were once an item of commerce, though always rarer than the pink variety (Figures 14 and 15).

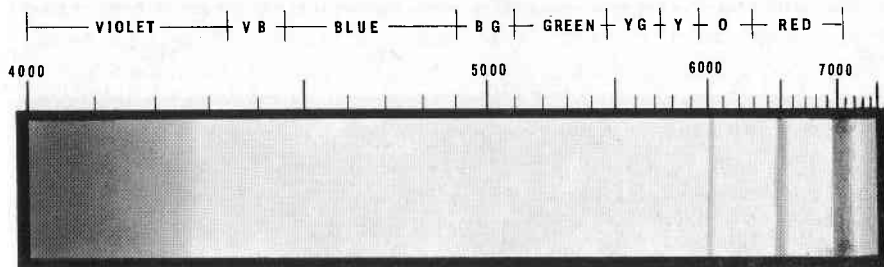


Figure 16. Very dark blue apatite.



Figure 17

A lot of natural sapphires, containing mostly small sizes but pleasant dark colors, fluoresced a chalky greenish-white under ultra-violet — both short and long wave. Since we do not expect this reaction but do expect synthetics to fluoresce, we examined the stones more closely and found that they were heavily oiled.

A very dark blue apatite crystal of 7.22 carats had normal apatite properties with the exception of the absorption spectrum which is shown in Figure 16.

The appearance on the market of a lovely intense red-orange topaz at a time when articles about the possible production of color in topaz by gamma and other radiation has prompted a number of clients to submit stones. Figure 17 is an especially handsome 40-carat stone. All of the stones seen were of the same color with the same characteristics of one that was recently left in the sun for more than three weeks without fading. The presence of chromium lines in the absorption spectrum (Figure 18) including a fluorescent line together with the red color under a color filter strongly suggests and probably proves that the stones are natural color. In addition, the high refractive index associated with known natural dark-colored topaz is reassuring. **HOWEVER, THE GEM TRADE LABORATORIES ARE USUALLY THE LAST TO KNOW OF NEW TREATMENTS.**

#### Greenish-Yellow "Citrine"

An unusual color of clear quartz which we have encountered several times in the laboratories is an intense greenish-yellow or yellowish-green resembling the color of some peridot or

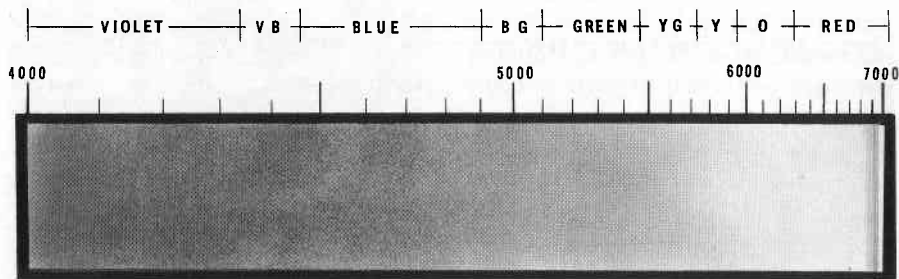


Figure 18. Red-orange topaz.

chrysoberyl. It is a color that gem dealers long associated with the production in Brazil cannot recall seeing. We are indebted to Dr. Nassau for research into the possible cause of color of this material. After a recent trip to Japan where he was presented with gamma radiated quartz, some of which was this peculiar color, he returned home to experiment with a section of a stone he owns and the known irradiated stone. It now seems quite possible to state with some degree of certainty that the color is due to irradiation — probably gamma radiation plus gentle heat treatment. The color is apt to fade in strong light or heat.

### Unusual Diamond Imitations

An intense bright yellow brilliant set in platinum with two tapered side baguette diamonds was examined for color origin. One look indicated that the engagement ring had received some wear as the stone showed small conchoidal fractures. It fluoresced an intense sulphur yellow color under long wave ultra-violet and was positively identified by the absorption spectrum as europium doped yttrium aluminum oxide — “YAG.” We were happy to have the absorption spectrum on record on page 374, *Figure 7* of the Winter 1968-69 issue of *Gems & Gemology*.

Another very light brown round brilliant was submitted from the trade. Its appearance resembled YAG with the expected polishing lines and imprecise facet junctions. It did appear to have considerable dispersion despite

rather poor make. The actual weight was 2.34 carats — surprising because it looked and gauged to be, if diamond, about 1.25 carats. It clearly had a very high specific gravity. This was calculated to be approximately 7.02, and the stone was identified as an example of Gadolinium Gallium Garnet, “GGG.” With a dispersion nearly as high as that of diamond (.038 versus .044) and a refractive index much higher than its relative, YAG (2.03 versus 1.833), and hardness perhaps near that of quartz, it might at one time have been of interest as a diamond imitation. The relatively higher cost of manufacture plus the high specific gravity — nearly twice that of diamond — and the lagging interest in imitation diamonds have mitigated against its use.

### Carvings, Carvings, Carvings

A time-consuming activity of the Laboratories which taxes the limit of gem testing instruments but which is a service we feel we must extend to our clients is the identification of items not used in jewelry. Such items as snuff bottles, statuettes, carved animals, etc., are often not well-polished or are carved in such a way that it is virtually impossible to get a satisfactory refractive index reading. *Figure 19* is a case in point. The client wanted 12 different parts of this exquisite composite carving identified. The bowl, bulbs and leaves, as well as the white petals, were all nephrite. The translucent buds were jadeite; the “water” in the bowl, rock crystal; the corolla, amber; and the stamens, seed

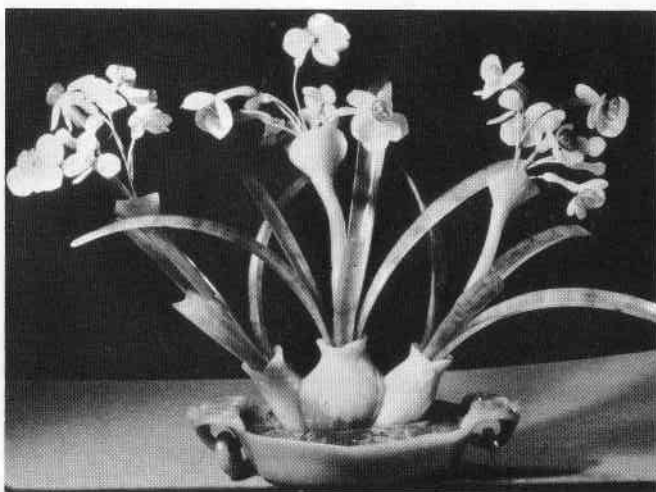


Figure 19

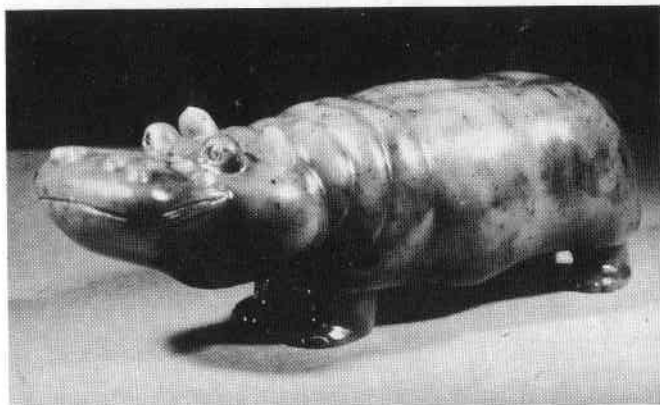
pearls. When the articles are well polished as the beautiful nephrite bowl (Figure 20) and the charming hippo with the ruby eyes (Figure 21) — also nephrite — the job is not difficult. Or, if the material is quite translucent and we can secure an absorption spectrum as we did for the exquisite vase and

cover of jadeite in Figure 22, our job is pleasantly expedited. Often, however, we are faced with the difficult task of determining the refractive index on large, complicated carvings which do not have an adequate surface for testing. Consequently, as with some rough material, we have had to develop new

Figure 20



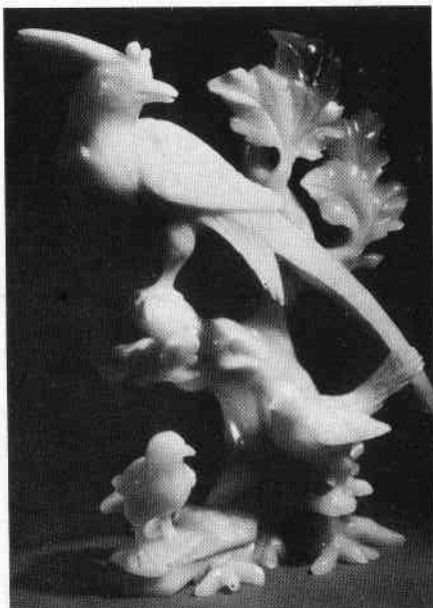
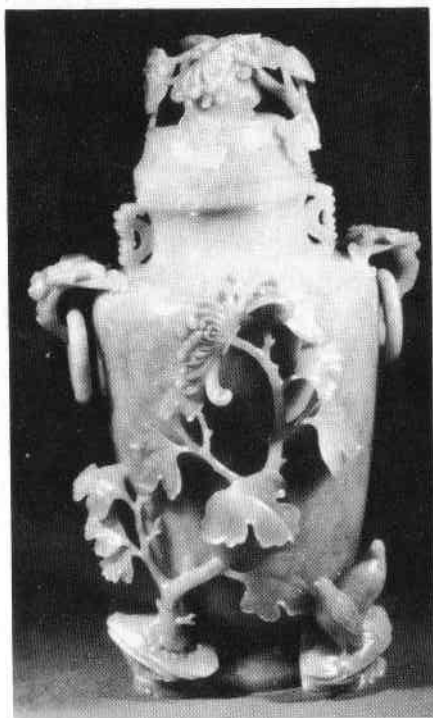




*Figure 21*

techniques for obtaining surfaces usable on the refractometer, such as for determining the various components of saussurite carvings. One such technique is to use a diamond

dust-impregnated cloth for putting a tiny polished area on a large, cumbersome object for which we could otherwise not obtain a refractive index. *Figure 23*, a beautiful bird carving,



*Figure 23*

*Figure 22*

illustrates a difficult specimen for obtaining a refractive index on which this technique was successfully used. Fortunately, it proved to be serpentine.

### Acknowledgements

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

To *Mrs. James Drilling* for many thousands of natural and synthetic stones which will certainly be noted as one of the most important donations for study use that we have ever received. We deeply regret the passing of our friend Mr. Drilling in New York in July of 1973.

To Graduate *Andrew Heinzmann* of H.R. Benedict Co., New York, for many very useful natural stones and a fine 0.92 carat Gilson synthetic emerald.

To *Mr. Richard Werdiger* of Diamond Abrasives Corp. for a set of color plates describing the application of industrial diamonds.

To GIA students *Barbara and Dick Rochow* for a useful selection of garnet and glass doublets and glass imitations.

To GIA student *Richard Swaebe*, Miami, for a lot of natural emerald crystals which proved invaluable in our spectroscopy study sessions at the recent American Gem Society Conclave in San Diego. They will be put to good use in all our colored stone teaching.

To our good friend *Dr. John Saul*

of Nairobi, Kenya, for a selection of 60 rough gem minerals from East Africa.

To GIA Graduate *Tom Mariner* of Union Carbide for his gift of synthetic stars, boules and rough synthetic emerald. Also, we wish to thank Tom for arranging for us to see samples of the latest work in the gem field of his company.

To student *Maurice Shire* of Sandawana Emeralds, New York, for a collection of large color photographs of gemstones produced by *Connaissance des Pierres Precieuses*, Paris. They will make attractive additions to the decor of our new quarters. We are also indebted to Mr. Shire for a set of French ring sizes and mandrel. Incidentally, French ring sizes are simply taken from the millimeter measure of the inside circumference of the ring. For example, our ring size #7 is 58 in France.

To Graduate *Leon Trecker*, Laguna Hills, California, for a selection of polished fire agates which proved helpful at the Conclave in San Diego during the sight identification sessions.

To *Allan Caplan*, New York, for apatite crystals also used at the San Diego AGS Conclave for spectroscopy study.

To *Harry Bookstone*, New York gem dealer, for responding so generously to our request for pale tourmalines and crystals for use in irradiation experiments.

# Crystal Balling Future Synthetic Gemstones

By T. H. MARINER, Gemologist  
Union Carbide Corporation

Of the 20 principal gemstone types, the following 11 (over half) have now been synthesized:

*Diamond:* By General Electric, *et al.*, using high temperature and pressure.

*Corundum:* By most of the common processes — Verneuil, flux, Czochralski, etc.

*Quartz:* By Bell Telephone Laboratories, *et al.*, hydrothermally.

*Beryl:* Hydrothermally and by the flux method by Union Carbide Corporation, *et al.*

*Topaz:* By the action of hydrofluosilicic acid on  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  in water at  $500^\circ\text{C}$  as reported by Webster.

*Spinel:* By Verneuil and Czochralski techniques.

*Zircon:* By flux method.

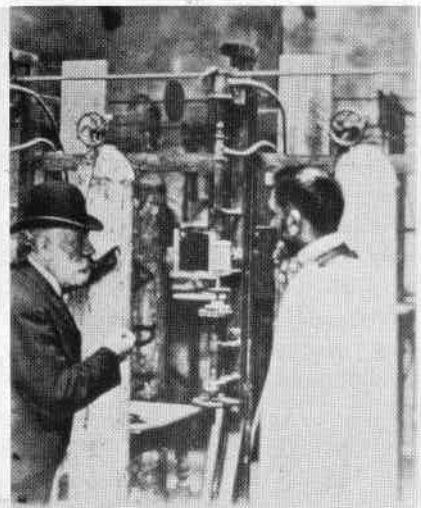
*Chrysoberyl:* By the flux method.

*Garnet:* Types such as YAG by the Czochralski method.

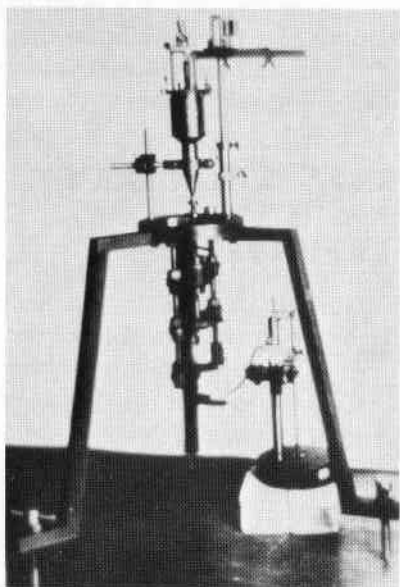
*Turquoise:* } By proprietary pro-  
*Opal:* } cesses of Pierre Gilson.

This does not mean all varieties of each have necessarily been synthesized.

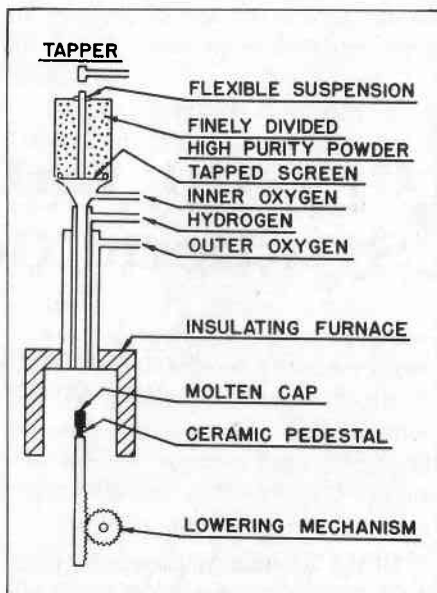
Chrysoberyl, for example, has been grown in several colors including the chromium doped alexandrite, but the



The father of gem synthesis, A. V. L. Verneuil, wearing the derby.



*Verneuil's original flame fusion equipment.*



*Diagram of flame fusion process.*

cat's-eye variety has so far escaped synthesis.

I have no doubt that a cat's-eye will ultimately be synthesized, if not by flux growth, perhaps by the Czochralski or hydrothermal methods. But rather than speculate on an occasional synthetic variety holdout, what do we know about the nine principal gemstone types that have never been made by man? Based on the present (known) state of the art, can we make some educated guesses as to their likelihood of synthesis? I think we can.

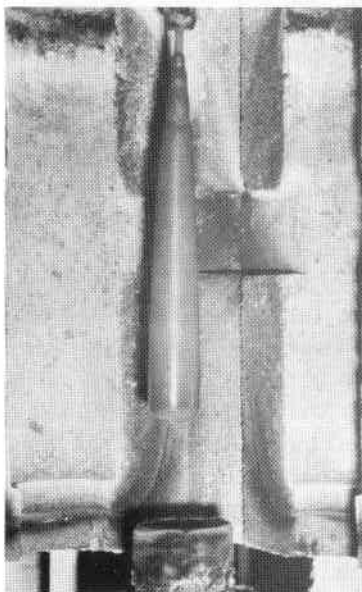
Three types can be dispatched right off.

First, the organics: amber, coral, shell, pearl, ivory, etc. Without getting in a semantic argument about "cultured

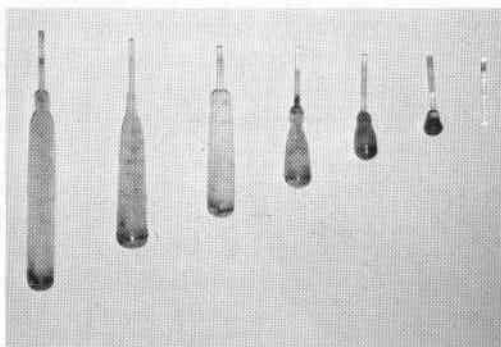
pearls," I think the organics as a group can be eliminated from this discussion. Man may plant the seed in the mollusk and harvest the result. But let's make no mistake about it. The mollusk grows the nacreous (pearl) layer.

The second gemstone type "to go" is lapis lazuli. Strictly speaking it isn't a stone or mineral at all; it's a rock, a mixture of minerals. Conceivably lazurite, one of its ingredients, could be synthesized, but that's really begging the issue.

And third, I would have to put hematite on the list of types inappropriate for this discussion. Natural hematite is abundantly available and inexpensive. Moreover, an imitation product, hemetine, made by compacting various powdered ingredients,



*A single flame fusion boule in growth position.*



*Growth stages in flame fusion boule development.*

already exists, and not because the material is cheaper. Rather, because cameos and intaglios can be molded from it, eliminating the cost of hand carving. Another use for this type of material is in the compacting of various shaped ferrite cores for electronic use.

With these three eliminated from consideration, our field of interest is now reduced to two polycrystalline types, jade and chalcedony, and the four following single crystal types: tourmaline, the feldspars, spodumene, and peridot.

Take the polycrystalline ones first:

*Chalcedony:* Since crystalline quartz and opal (hydrated amorphous quartz) have both been synthesized, one intuitively feels synthesis of chal-

cedony should be possible. But whether or not this would be economically meaningful is something else again.

Properly doped fused quartz, for example, conceivably could be devitrified into a lovely chrysoprase, or a ground frit of the same fused quartz might be sintered to produce similar results. But fused quartz is a fairly expensive raw material in its own right. So unless its formability in the glassy state (or compactability as a frit) offers a fashioning advantage, it is unlikely that a chalcedony so synthesized would be competitive for gem use. Indeed, natural chalcedony is so inexpensive that unless a process were perfected for its research value, or a chemically unique material were

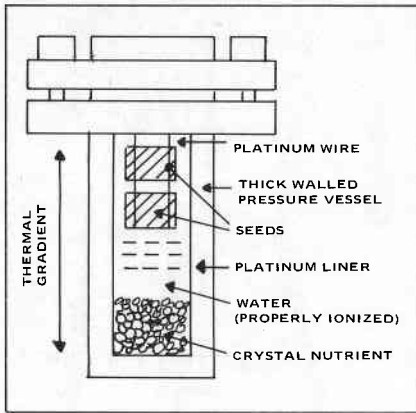


Diagram of a hydrothermal reactor.

required for some non-gem (industrial) use — perhaps as a catalyst — there would be little point in synthesizing chalcodony.

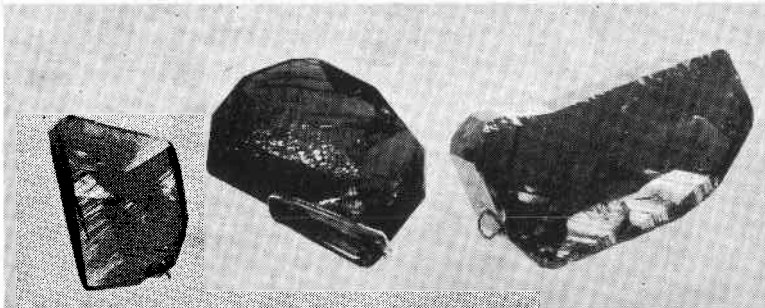
*Jade:* With the possible exception of toughness, nephrite is really out-classed by jadeite on all counts. Consequently, if synthesis is contemplated, jadeite is certainly much to be preferred. And all else being equal — for gem use at least — one would probably strive for the highly prized Imperial green color at that.

Interestingly, from a chemical point

of view, jadeite  $[\text{NaAl}(\text{SiO}_3)_2]$  is much simpler and would probably be attempted first anyway. Exactly which process would be used is sheer conjecture, but calcination of analcite or reduction of albite yield balanced equations (on paper). Another very interesting possibility would be the fluxing of sand ( $\text{SiO}_2$ ) with the zeolite natrolite driving off hydrogen. This should yield a glass with the jadeite formula. If this were then ball milled to a frit and compacted by sintering, the result might meet all the common properties of jadeite.

Would it qualify as a synthetic? Who knows? Remember, spinel grown by the Verneuil flame fusion technique is not a *true* synthetic either. Its formula is  $\text{MgO}_{3.5}\text{Al}_2\text{O}_3$ , not  $\text{MgOAl}_2\text{O}_3$  as in the natural stone. It is this lack of stoichiometry that distorts the crystal and has forced gemologists to coin such terms as anomalous double refraction to account for its optical (mis-)behavior.

And, of course, “synthetic emerald” grown in a molten flux of, say,  $\text{V}_2\text{O}_5$ , can’t possibly have multiple phase inclusions of water and gas as found in nature. It’s really not



Linde-created emerald crystals hydrothermally grown.

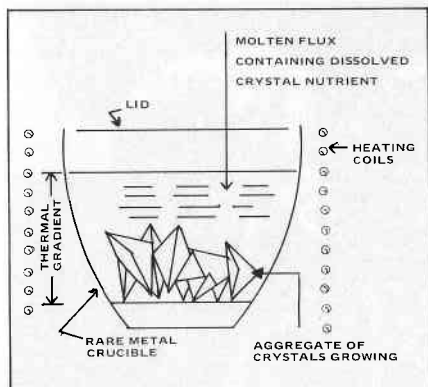


Diagram of the flux process.

surprising that flux grown “synthetic emerald” has different values in the properties tables from the natural crystal. But then they never did call it synthetic beryl, did they?

True synthesis of spinel is, of course, possible by the Czochralski technique, and beryl (green or otherwise) can be synthetically grown hydrothermally. But these distinctions

are more likely to be noted in the laboratory than in the trade.

I suspect the first “synthetic jadeite” may invite similar hair splitting also.

Now let’s look at the four single crystal types:

*Spodumene*: From a practical point of view, there is really little to recommend spodumene even as a natural gemstone. Strong cleavage in two directions makes the crystals difficult to fashion, and rather short on durability. Two varieties, *kunzite* and *hiddenite*, are sought by some collectors because of their rarity, but that’s hardly a property that translates well into a synthetic.

Nevertheless, if anyone wished to grow synthetic spodumene, perhaps for an industrial use to utilize its strong optical properties under U.V. or X-rays, it probably could be done by either the flux or hydrothermal methods. It’s also possible that being a member of the pyroxene group it



Typical crystal aggregate grown in flux.

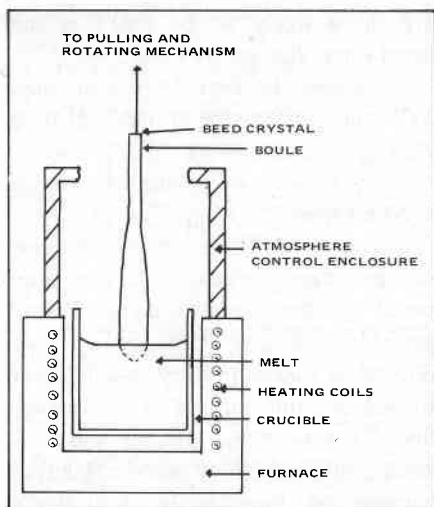


Diagram of the Czochralski process.

A YAG boule grown by the Czochralski technique.



might be grown as a parallel (academic) exercise in the pursuit of another pyroxene, jadeite.

**Peridot:** A plentiful supply of peridot and no very spectacular properties all combine to keep this gemstone relatively inexpensive. These very same properties probably preclude any commercial (gem) interest in synthesis. The formula  $(\text{Mg,Fe})_2\text{SiO}_4$  suggests it could be grown by either the flux or hydrothermal methods. But, like spodumene, academic interest is the only reason I can think of that would prompt it.

**Tourmaline:**  $(\text{Na,Ca})(\text{Li,Mg,Fe,Al})_9\text{B}_3\text{Si}_6(\text{O,OH})_{31}$ . Seeing that formula, one is inclined to say "forget it" as regards synthesis. Actually, even that formula is wanting, because it fails to list potassium, manganese, and

fluorine, which may also be present. Fortunately, if synthesis were really wanted, the "formula" could be skirted by using worthless chips of natural tourmaline as nutrient in a hydrothermal bomb. In that event, presumably the more desirable red color would be sought, perhaps mixed with green and/or colorless. All of which, fortunately, stem from the same general type — that which is rich in the alkalis lithium, potassium and sodium.

From a practical point of view, however, tourmaline is far too abundant in nature to warrant its synthesis just for gem use. Indeed, unless unique specimens are sought for other purposes, perhaps to utilize tourmaline's piezoelectric, or optical, properties, synthesis would seem rather unlikely.



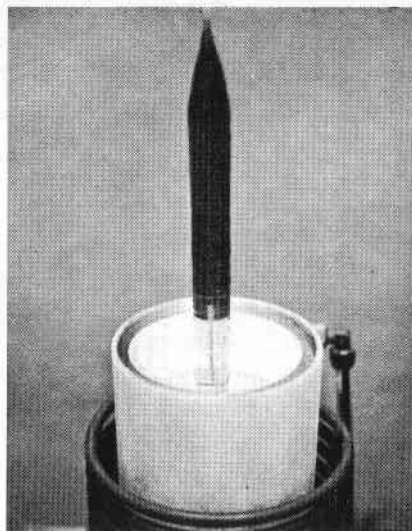
*Feldspar*: If any of the foregoing stones were unlikely to be synthesized because it was prevalent in the natural form, the argument is doubly so with feldspar. Taken as a total group, it is the most abundant mineral on earth. Even the relatively rare moonstone variety of orthoclase is too inexpensive to warrant synthesis, and other varieties are actually used for architectural materials, such as labradorite.

Summing up. Of the nine principal gemstone types that have not been synthesized to date, really only one, jadeite, would seem to be "probable" in the near future. Whether or not the product will be a true synthetic or just a very close substitute is debatable, but I believe one will be forthcoming.

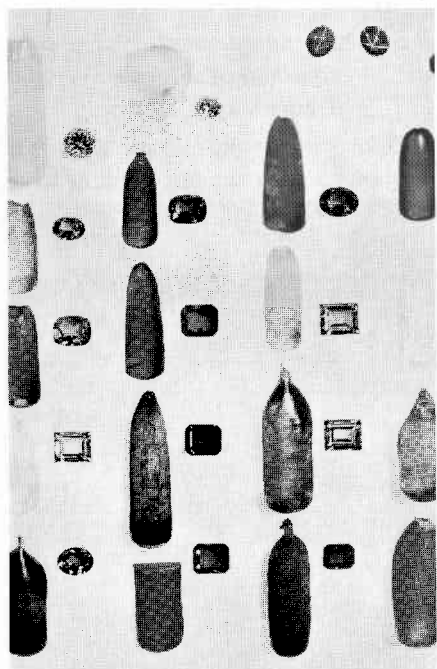
Some, if not all four of the single crystal types undoubtedly are possible of synthesis but economically offer very little reason to do so. Accordingly, their synthesis for gem use would have to be rated as unlikely.

Incrementally even less likely still are chalcedony, hematite, and lapis lazuli.

And with all due respect to T.V., the synthesis of organics would have to be rated a "mission impossible."



*Actual Czochralski unit showing the "pulling" of a boule.*



*Boules and their end products — gemstones.*

# Developments and Highlights at **GIA**'s Lab in Los Angeles

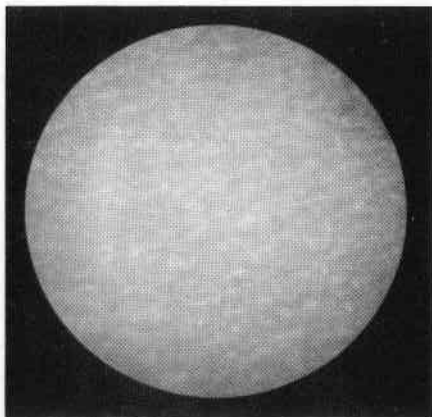
By RICHARD T. LIDDICOAT, JR.

As usual, the period between the last report and this one has seen some very interesting submissions for analysis.

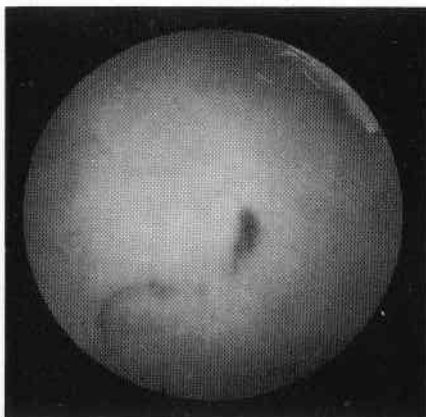
## Synthetic Turquoise Under Magnification

Upon examining some synthetic turquoise within the last week or two,

we were pleased to note that under high magnification it reveals a structure that should serve to identify it very readily. With a magnification of 50X or slightly less, the appearance of the surface suggests the presence of millions of tiny spheres that have been compacted. *Figure 1* was taken under approximately 50X. At even higher



*Figure 1.*



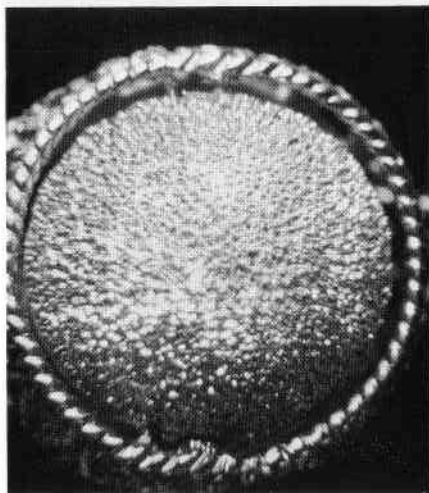
*Figure 2.*

magnification, the tiny spheres, of which there are many in each of the darker patches observed in the mottled surface in *Figure 1*, can be seen individually. With this comparatively low magnification, they do not appear as spheres. This mottled appearance is characteristic compared to the rela-

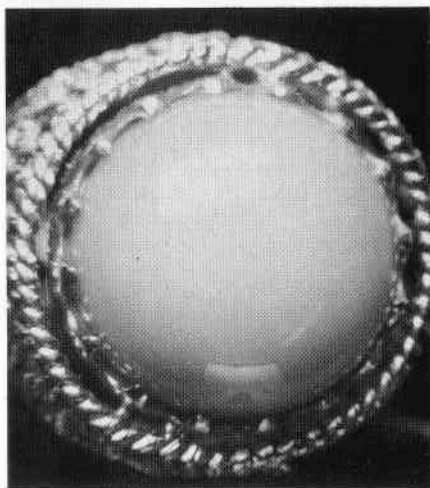
tively even, very fine grained texture of natural turquoise as shown in *Figure 2* under the same magnification.

### An Unusual Ring

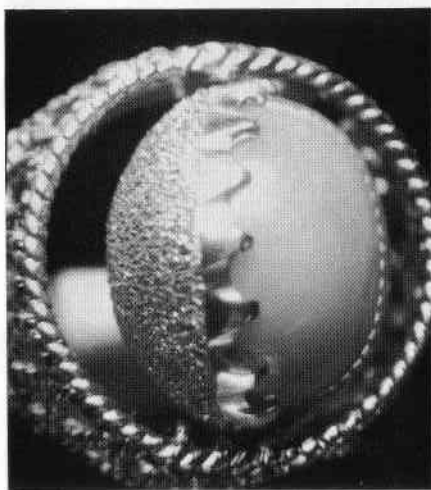
We had an odd gold and chryso-prase ring submitted for identification. When we first saw the ring we wondered why it was in for identification because it had an interestingly textured gold top with no gemstone in evidence. Upon close examination it became obvious that the gold crown was attached to the shank in a manner that permitted the wearer to rotate the center from the position in which the textured gold was in position to be in view to a second position in which the gold was down and a lovely chryso-prase in the upright position. *Figures 3, 4 and 5* show this unusual mounting.



*Figure 3.*



*Figure 4.*



*Figure 5.*

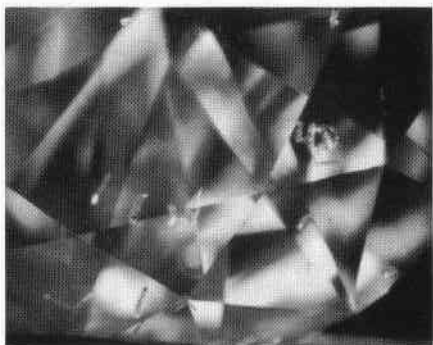


Figure 6.



Figure 7.

### A Worm's-Eye View

We had a large brownish-pink diamond in for a determination of the origin of color. We noted under magnification what at first glance appeared to be well over a dozen laser holes. Upon closer inspection, it became apparent that some did not reach the surface, and those that did were not conical nor were they aimed at any inclusion that might have appeared black. We concluded that these were probably included crystals of peridot and pyrope. These are particularly well

shown in *Figures 6, 7 and 8*. *Figure 9* shows that there were some feathers associated with them.

### Irregular Gas Vesicles

In the course of routine identifications we encountered a glass with gas bubbles that looked so much like included crystals or two-phase inclusions that Chuck Fryer photographed the inclusions. From this photograph one would not be inclined to suspect glass, except for the fact that the bubbles are lined up in gently curving lines (*Figure 10*).

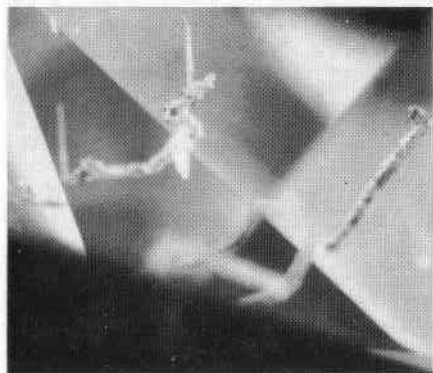


Figure 8.



Figure 9.



Figure 10.

### Unusual Amber

Figure 11 illustrates an unusual combination of the man-made and natural. This photograph shows a number of pieces of amber encased in plastic. One of the pieces of amber is seen near the right-hand tweezer arm as a rounded pebble. In a slightly more

Figure 11.

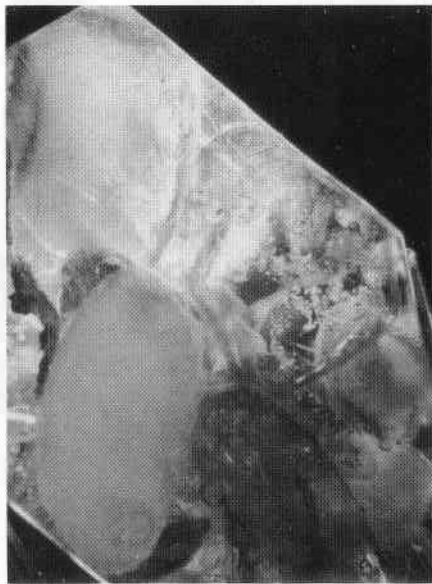


magnified version, shown in Figure 12, one cloudy, rounded amber grain is located at the lower left portion of the photograph, and two other more transparent grains are above it on the upper quarter to its right.

The extent of efforts that are devoted to altering stones or making substitutes are exemplified in Figure 13, a very realistic amber substitute. This is a plastic with an R.I. of around 1.56 or 1.57. It showed no fluorescence under long wave ultra-violet. When touched with a hotpoint the realistic-looking substitute gives a very acrid odor, quite unlike that of amber.

Figure 14 shows adjacent pieces of jadeite in a necklace. The one on the left appeared to contain a very coarse crystal of jadeite viewed down the long axis. The almost square ( $93^{\circ}$ – $87^{\circ}$ ) outline is characteristic of the monoclinic pyroxene. It is very rare to

Figure 12.



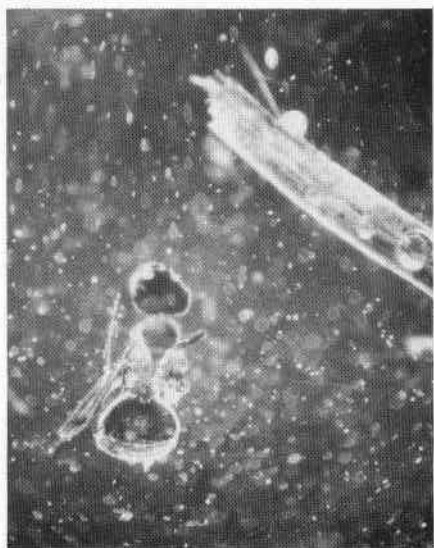


Figure 13.

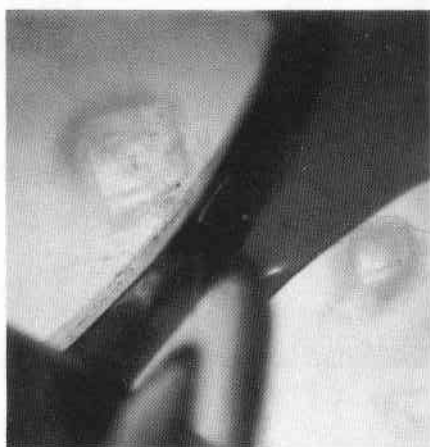


Figure 14.

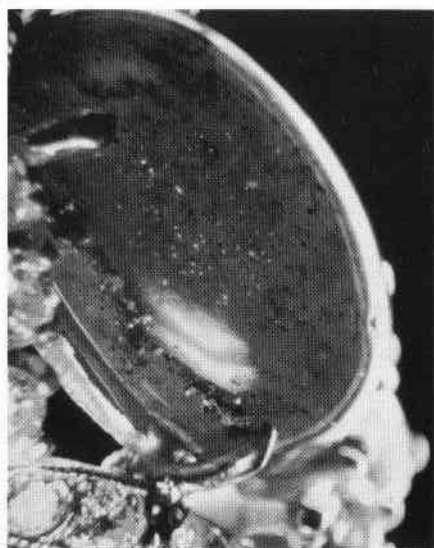


Figure 15.

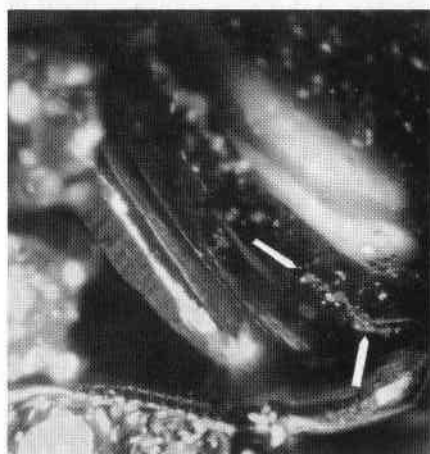


Figure 16.

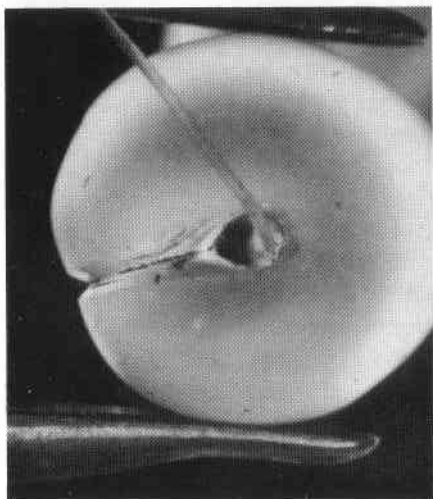


Figure 17.

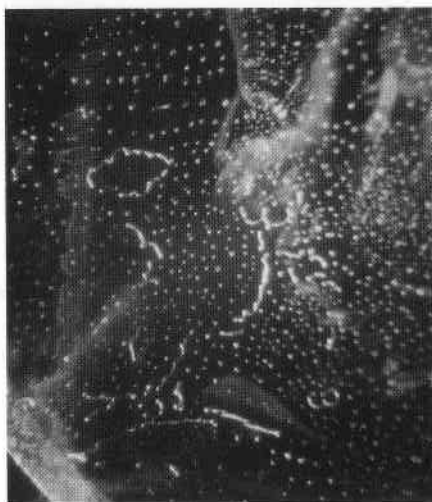


Figure 18.

see such a coarse crystal in a cut jadeite.

Pyrite is, of course, a common inclusion in Colombian emerald, but we don't recall seeing one with such a heavy concentration as was evident in a cabochon sent in for identification a short time ago. It is shown under 10X in *Figure 15* and under about 30X in

*Figure 16*. Whole zones, such as that shown by the arrows in *Figure 16*, were at least 50% pyrite.

### Strange Glass Beads

In the course of routine identification we encountered a strand of green beads with a surface dulled and



Figure 19.



Figure 20.

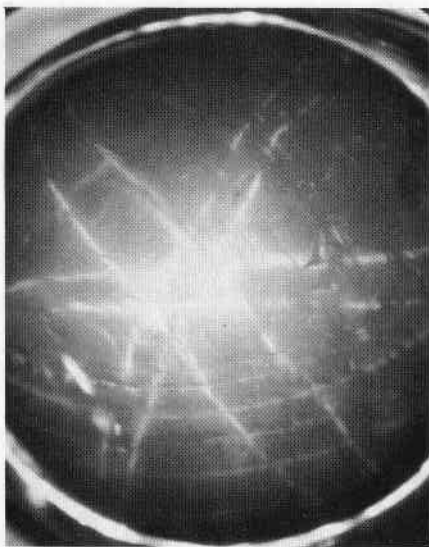


Figure 21.

coarsened from long wear. Close examination of the beads disclosed the appearance shown in *Figure 17*. It can be seen here that soft glass was bent into a circle to form the beads. The two halves are joined at the left. We do not recall having seen glass beads formed in this fashion.

#### Unusual Inclusion Patterns

We think of corundum first when we think of the so-called "fingerprint" inclusions. *Figure 18* shows a pattern that could easily be accepted as a fingerprint by a casual observer. Closer attention to the nature of the inclusions shows them to be gas bubbles, many of them irregular in outline. The host was a synthetic sapphire. The pattern could easily fool the casual observer.

#### Emeralds or Synthetic Emeralds

Early this year in the course of routine testing a stone that might have been synthetic or natural emerald, we encountered a zone which was very reminiscent of the layer next to a seed in the Linde hydrothermal synthetic emeralds. As seen in *Figure 19*, they seem to contain dustlike or bread crumb inclusions in a very prolific pattern of spots in one plane. Examination of the rest of the interior disclosed good three-phase inclusions in another portion of the stone (*Figure 20*). Thus, this clearly was a natural rather than a synthetic emerald.

#### An Unusual Star Ruby

On quite a number of occasions we have seen star corundum with 12 rays, but in every instance they all crossed at the same point. In *Figure 21* we see a stone that is very unusual in that it shows two distinct rays in each of the three directions, with a very significant separation between the two long rays in each of the three principal directions. We attribute this to a combination of the needle-like inclusions that give rise to an ordinary star plus twinning to make the second set of rays.

#### Rich Blue Kyanite

Recently we had a chance to examine some of the most magnificently deep blue kyanite as it has ever been our pleasure to see. Its source is East Africa from what is apparently a new source. We hope this new source will become a sufficiently prolific producer to make available to collectors



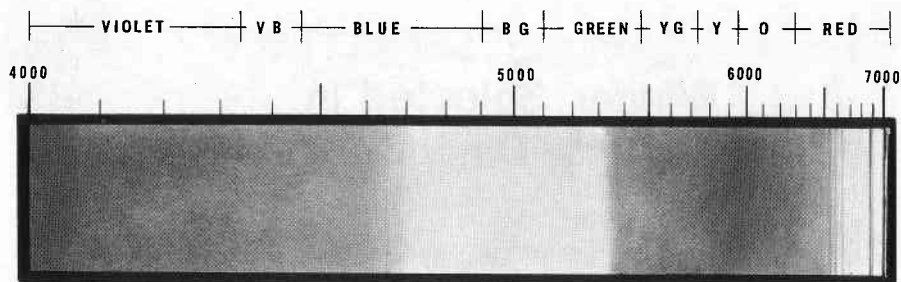


Figure 22. Africa-Blue Kyanite.

and even to gem fanciers such rich blue kyanite. Its unusual spectrum was drawn by Chuck Fryer for this column. It is shown nicely in *Figure 22*.

### Acknowledgements

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

To *Joseph Adamski* through *K. N. Hemmenway* for a rare synthetic NiO boule for reference and research.

To the *Association of Japan Gem Trust* for a fine cabochon and slab of cat's-eye actinolite to be used in our ongoing research projects.

To *Dr. Edgar F. Borgatta, G.G., Ph.D.*, of Gempro Distributors, Rupert, Vermont, for a large donation of nine pounds of tumbled garnets to be used in our gem identification classes.

To *Ralph Brideaux*, of Ralph's Gems and Jewels, New Britain, Connecticut, for a fine assortment of quartz tiger's-eye, chalcedony, onyx, quartz, and other natural stones for classroom use.

To *Ben Gordon, G.G.*, of Gordon Jewelry Corp., Houston, Texas, for a very large and generous assortment of

cut stones including lapis lazuli, nephrite, quartz, coral, shell cameos, garnets, glass doublets, foilbacks, and synthetic stones, which will be put to good use in the gem identification classes.

To *John Peterson*, of Gemstones Ltd., for slabs of dendritic opal, natural and synthetic faceted sapphires and miscellaneous doublets for our gem identification course.

To resident student *Waveney Philipe*, of Enachu Diamond Traders Ltd., Charlestown, Republic of Guyana, for a welcome donation of 100 carats of good study specimens of rough topaz for use in the resident stone testing sets.

To *Marcus Switzer*, GIA student, of Switzer's School of Faceting, Manhattan Beach, California, for his personal assistance and six hours' use of faceting equipment in the preparation of colored slide presentations to be used in the GIA Colored Stone and Gem Identification resident courses. Also, our thanks for one pound of Burma gem gravel for use by resident students in gem identification and a fine sample of synthetic sapphire made by the pulling method for our reference collection.

## Winner Selected in Jewelry Design Contest

Early in 1973, a scholarship fund was established in memory of Mr. George A. Schuetz, former president of Larter & Sons, Inc., and a long-time friend of the Institute, by Charles E. Butler, Ralph W. Landis, Leo J. Dolan, Richard Shreve, and Arnold A. Schiffman.

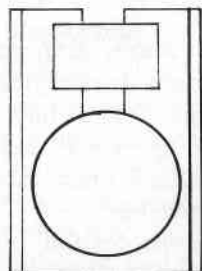
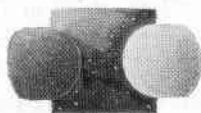
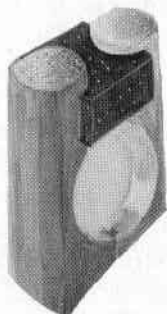
This scholarship fund was initiated as an award for the best design of a piece of men's jewelry submitted to the George A. Schuetz Memorial Fund Jewelry Design Contest. Entries to the contest were accepted at GIA headquarters in Los Angeles through December 31, 1973, and judging took place on January 21, 1974. A total of twenty-two entries were submitted to the contest.

Members of the Panel of Judges were Glenn R. Nord and J. Burton Streeter, both of the GIA faculty; Miss Lilyan Collard, jewelry designer for Donovan & Seamans Co., Los Angeles;

and Robert Emerson, manager of Cartier Inc., Beverly Hills.

Selection of the winner was a difficult task for the Panel, since many fine designs were submitted. The entry receiving the largest number of votes was designed by Mr. Ikuo Sato of Tokyo, Japan, currently residing in Los Angeles. His design for a man's ring, pictured below, uses both yellow and white gold set with a square lapis lazuli cabochon.

The \$300 scholarship awarded to the contest winner may be used for any jewelry-related training. Mr. Sato, who has completed both GIA's Resident Program in Gemology and in Jewelry Design, plans to use his scholarship to study casting. We congratulate him on his excellent design, and we also thank all the other entrants for submitting their designs to the contest.



*Lapis lazuli enhances avant garde white and gold man's ring designed by Ikuo Sato.*