Gems and Gemology

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Richard T. Liddicoat, Jr.
Editor

Jeanne G. M. Martin
Assoc. Editor

On the Cover

An award-winning diamond clip-brooch designed by Marc Koven of New York City. This versatile clip, with a latticelike arrangement of diamond baguettes and brilliants and with baguette-diamond wings, may be worn as a pendant or as a pin. The detachable baguette wings become a pair of clips and the pear-shaped solitaire is detachable for wearing on a chain.

Photo Courtesy Dorothy Dignam
N.W. Ayer & Son, Inc.
New York City

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Spectroscopic Recognition of Yellow Bombarded Diamonds and Bibliography of Diamond Treatment

G. ROBERT CROWNINGSHIELD
Director of Eastern Headquarters GIA

One of the problems presented to the jeweler of the Atomic Age is that of determining whether the color of a diamond is natural or produced by some type of atomic bombardment.

Descriptions of the various methods of treating diamonds and the recognition of certain types have been given by several authors. For the interested reader, a bibliography of pertinent articles in English appears at the end of this article. The purpose of this article is not to summarize or to repeat, but to add recently acquired information regarding the detection of treatment in yellow diamonds.

At the time of this writing, the colors of treated diamonds that are available commercially are various tones and intensities of yellowish green to bluish green, brown to orangy brown, and yellow to brownish yellow. Although blue and greenish-blue stones have been reported and we have seen a few brownish-red tones, they do not seem to be available commercially.

Unless green *naturals* are present on a dark-green diamond (an indication of "green-skinned" stones from Venezuela or Bahia), few dealers today accept as natural any dark-green stones. Radium treatment is suspected if the stones show blackish surface discolorations and if they "take their own pictures" when exposed to a photographic or X-ray film for a period of 12 to 36 hours. Stones that have been surface treated by deutron bombardment in the cyclotron are often easy to identify: if only the top of the stone has been treated, dark bands will be seen in the crown-facet reflections; if only the bottom of the stone has been treated, a star-shaped zone of color

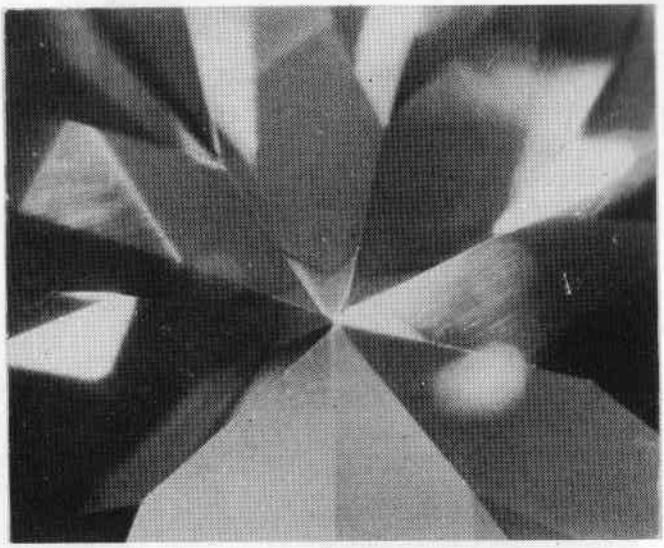

Figure 1

penetration will be seen at the culet *(Figure 1)*. But today, many diamonds are bombarded with fast neutrons, especially in the atomic pile. Here the penetration is throughout the entire stone (or uncut crystal), thus the visual evidence present in surface-treated stones is eliminated.

The subsequent heat treating of dark-green stones may change the color to tones of brown and yellow. If they were originally surface treated, the visual evidence remains, although somewhat more difficult to see in the yellow stones. Of course, if the stone is neutron treated, no visible evidence is present, either before or after heat treatment.

As pointed out above, dark tourmaline-green-colored diamonds are almost universally considered to be treated, whether visible evidence is present or not. In the case of brown stones in which no evidence is present, not too much anxiety is aroused, because the difference in value between the average natural brown stone and its treated counterpart is negligible.

However, when one considers fancy yellow or brownish yellow (golden) colors, the story is different. Fine canary diamonds have long commanded a high price. Today, high prices are still being paid for deep-yellow stones by dealers who have yet to learn that these colors are available at modest cost in treated stones and that there is no safeguard in knowing that is was cut from colored rough. Further, many dealers are still unaware that many of these stones are visually unidentifiable, although men with long experience are frequently able to "sense" that something is wrong with the color of some of the treated stones. This is particularly true if the original color of the stone was a dark cape. A fine white stone will take on the best of the treated colors, whether green or yellow. These are not easily "sensed," since they appear brighter and more natural, particularly the yellow to golden yellows. It would appear that the treated color is superimposed on the original body color, so that the darker the original color, the more subdued the brilliance of the finished stone.

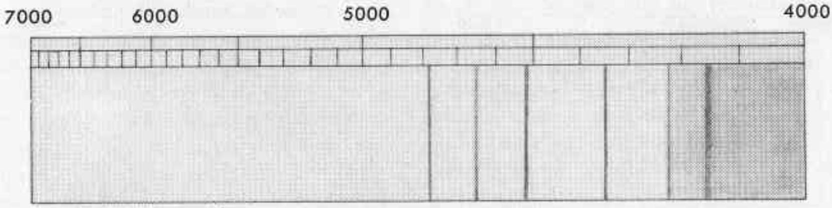

Figure 2

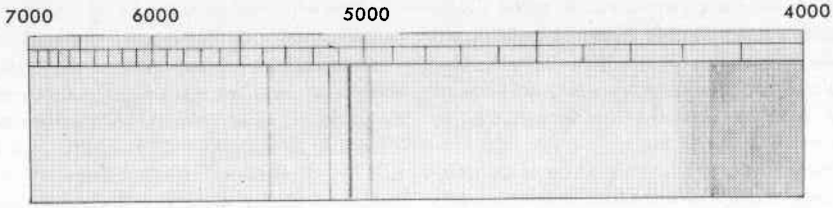

Figure 3

Some authorities have suggested that perhaps the treating of colored diamonds may one day be disregarded, just as the heating of such stones as citrine, aquamarine, and zircon is largely disregarded today. However, the jewelry trade has not yet reached that point, and the laboratories of the GIA have been under some pressure to develop some means of distinguishing between natural and treated stones, particularly those of a yellow color.

The avenue of investigation that has offered the best possibilities is the observation of the absorption spectra with a spectroscope.

Although the diamond has been studied extensively and two fairly consistent types of absorption spectra have been noted, much remains to be determined regarding the inter-relationship of color, fluorescence and spectral absorption.

Figure 2 shows a complete cape-series absorption spectrum. The spectrum may be observed either in part or in its entirety in almost all diamonds with a yellowish cast, particularly in those stones that show a bluish fluorescence and a yellowish phosphorescence under ultraviolet light of 3650 Å. The darker the color, the stronger will be the lines; with 4155 Å the strongest (also often seen in stones of nearly colorless body) and most persistent with a moderately strong line at 4780 Å and weaker bands at 4650 Å and 4520 Å. Very weak lines at about 4350 Å and 4230 Å may sometimes be seen in very dark cape stones with ideal illumination of the spectroscope. However, they have not been included in *Figure 2.*

Certain pale-yellow diamonds, particularly those with intense orange or yellow fluorescence, and certain rich yellow to yellow-orange diamonds may show no absorption lines whatever. The latter we think of as true canary diamonds, in contrast to dark cape stones although the test is by no means accepted by the trade. Therefore, "one man's canary" is frequently "another man's off color."

Figure 3 is the spectrum observed in a rather rare brown diamond with a green to greenish-yellow fluorescence. It sometimes has an almost liquid-soap appearance, with

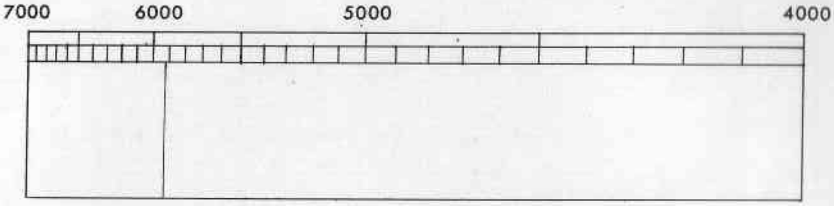

Figure 4

intense orange flashes from the back facets when the stone is observed in daylight. Occassionally, natural yellowish-brown stones may show the 5040 Å line in addition to the 4155 Å line.

Early in January, 1956, while examining a large bright-yellow brilliant-cut diamond, the members of the New York Laboratory staff noticed a distinct absorption line in the spectroscope that, as far as could be determined, had never been recorded in the literature on the absorption characteristics of diamond. No visual evidence of treatment could be observed, and we were forced to issue a report to the effect that "... no evidence was observed that, in the opinion and experience of the Laboratory, would prove the origin of the color of this diamond."

The appearance of the mysterious line at what we estimated to be slightly over 5920 Å puzzled us. I wrote immediately to Mr. Basil Anderson, a Director of the Precious Stone Laboratory of the London Chamber of Commerce, London, to inquire if he had ever observed such a line in yellow diamonds. Mr. Anderson, one of the world's most ardent champions of the use of the spectroscope in gemstone identification, had, with Mr. C. J. Payne, recently completed a 40-part comprehensive article in *The Gemmologist* on the use of the spectroscope, of which part #35 was devoted to the diamond (The Gemmologist, July 1956). Mr. Anderson replied that he had observed a line at approximately 5920 Å in a yellow crystal in 1945. He did not include this line in the article mentioned above (*see Figure 4*).

Meanwhile, we made arrangements to observe as many known treated yellow diamonds as possible. We are indebted to Mr. Theodore Moed, New York City, one of the few dealers in treated diamonds, for making available his entire stock of treated and untreated stones for our examination.

With careful observation, we were able to find the mysterious 5920 Å line present in every yellow to golden-yellow treated stone, as well as in some of the brown treated stones, with the exception of a culet-treated greenish yellow stone with an intense sulphur-yellow fluorescence. Since our initial observation of treated stones, we have seen hundreds varying in size from .05 carat to several carats each, both cyclotron-deutron treated and neutron-pile treated, and all have shown this line with the above exception.

Of special interest was a series of 34 cape stones, which we were allowed to examine before treatment and again a week later after bombardment in the atomic pile at Brookhaven, L. I. The stones that are ordinarily used for bombarding are of the typical inexpensive cape color. In this case, 20 of the stones showed a rather typical combination of a bluish fluorescence and a yellow phosphorescence. 13 of the stones showed yellow fluorescence and yellow phosphorescence in varying strengths. All but one of the stones, when examined with the spectroscope, showed the typical cape spectrum in varying degrees of strength and completeness, related directly to the depth of color. The remaining stone showed intense yellow-green fluorescence and no phosphorescence. Instead of the cape spectrum, it showed a pair of absorption lines at approximately 5040 Å and 4970 Å. This stone was returned untreated as "... too fluorescent to be predictable."

All of the other stones except one (which was left green) were returned varying in color from golden brown to fine yellow. As was expected from the fact that they were pile treated, no visual evidence of treatment was observed. In all but the green stone, the 5920 Å line was readily visible in the spectroscope. In addition, the darker brown stones showed the 5040 Å line in varying intensity. Clearly, then, bombardment and subsequent heating had introduced the 5920 Å line as well as the 5040 Å line.

Another single stone of interest that we examined both before and after treatment in the atomic pile was a pear-shaped stone of approximately three carats, the untreated color of which was very dark cape, just short of being an acceptable fancy color. It showed the normal complete cape spectrum and had yellow fluorescence and yellow phosphorescence. When it was returned after treatment, it was just perceptibly darker in color; in fact, not really enough darker to be much increased in value. Even so, the 5920 Å line was visible, together with a weak 5040 Å line. Probably the treating operator was overcautious in making the stone a dark enough green initially, so that when subsequent heating took place the stone was not as dark as desired. The presence of the 5040 Å line, according to R. A. Dugdale (British Journal of Applied Physics, 1953, Volume 4, P. 334), is good evidence that the heat treatment took place at under 350°C. Dugdale reports that the 5040 Å line is lost when the stone is heated above 400°C. The fact that the fluorescence and phosphorescence were virtually the same before and after treatment is in further agreement with Dugdale's work.

Our next problem was one that offered more difficulty: securing natural yellow diamonds of unquestioned history. Our thoughts turned to collections that we knew about. We had once examined a private collection of some 63 fancy-colored diamonds for a client and had noted several surface-treated greens and browns, together with some yellow stones that showed the suspected absorption band at 5920 Å but no visible evidence of treatment, and some dark-yellow stones that showed nothing but the regular series of cape absorption lines in the spectroscope. Several of the rich true canary stones showed nothing visually or in the spectroscope, as expected. Unfortunately, we were unable to contact the collector to determine just when each of the stones had been added to the collection. We have rather arbitrarily set 1950 as the date after which any yellow diamond is suspect, although we examined our first really attractive yellow-treated diamonds in 1952.

In the course of the past ten months we have observed as many known natural yellow diamonds as we could find. We are indebted to Wiss & Sons, Inc., for allowing us to examine the personal collection of Mr. Jerome B. Wiss. We are indebted also to Dr. Brian Mason, curator of the American Museum of Natural History's gems and minerals, for allowing us to examine all available rough and cut diamonds. We are further indebted to the following New York firms and individuals: Mr. Ralph Esmerian; Avvocato and Tuch, Inc.; Lazare Kaplan and Sons, Inc.; Harold Cohen, Inc.; Martin Harmon, Tiffany and Co.; Gladys Hannaford, N. W. Ayer & Sons, Inc.; Wolf Leibler and Sons; Harry Wachsberg, Barclay-Roberts, Inc.; and many others.

In only two cases did we examine yellow stones with uncertain histories in which the 5920 Å treated line was present. One stone, an intense chartreuse-yellow with bright yellow fluorescence and no phosphorescence, not only showed the 5920 Å line but also the 4155 Å, 4780 Å, and 4650 Å lines of the cape series and a line at approximately

5500 Å and one at approximately 5640 Å. The latter two lines are not recorded in the literature, but both have been reported in private correspondence by Dr. E. Gubelin and Mr. Basil Anderson. The other mystery stone also was an intense greenish yellow with similar, but weaker, fluorescence. It was a small stone, and the only lines observed were the 5920 Å line and the 4155 Å line. Although neither of these stones was of the color to be expected from treatment, the fact that their histories are not known for certain does raise a warning signal not to accept as unqualified proof of treatment the presence of the 5920 Å line.

Our next effort was to examine nongem rough which, it was felt, would probably not have tempted anyone to treat. We are indebted to Harry Wachsberg and others for this part of our investigation. In none of the hundreds of colored industrial stones observed, many of good color but badly flawed or poorly textured, did we observe the 5920 Å line.

Meanwhile, Mr. Basil Anderson made valuable spectroscopic observations that he communicated to me. Most of this work substantiated the work reported in this paper. Dr. Edward Gubelin also examined some 35 yellow diamonds in his private collection, with virtually the same findings that we have had whenever we have examined known natural yellow stones. I am indebted to these eminent gemologists for their assistance.

It is perhaps significant that the treated yellow diamonds that have appeared on the market to date tend toward a brownish yellow and not toward a greenish yellow. Only in cases where an unusually fine white stone has been treated does the color approach a yellow without a brownish cast. Such stones, of course, are not economical to treat.

A word of caution to the gemologist who would test diamonds for absorption lines in the spectroscope: Robert Webster suggests in his *Compendium,* a strong source of light is required for the observation of absorption lines in diamond. Only the 5040 Å line and the 4780 Å line are readily visible in natural diamonds (when present). Fortunately the 5920 Å line in treated stones can be detected with a lower powered light source. Direct transmitted light, such as a pearl "candler" or the iris diaphragm of the Gemolite, has disadvantages for some observations in diamond. First of all, the light does not travel as far as when a strong light is spotted through the pavilion to be totally reflected off the table and thence to the instrument. Further, diamond's high refractive index makes direct transmission difficult. Perhaps more important is the fact that the "treated" lines are present at room temperature, but will disappear temporarily if the stone becomes heated to the point where the stone becomes uncomfortable to hold.

On the basis of our findings to date, the laboratories of the GIA have decided to issue reports on yellow diamonds of a more positive nature than formerly. If the 5920 Å line is present, and particularly if it is accompanied by the 5040 Å line, our report will read: "On the basis of investigations conducted to date and continuing, it is the opinion of the laboratory that the presence of an absorption line at 5920 Å in the spectroscope is strongly indicative of color induced by atomic bombardment."

In the case of brownish-yellow to yellow diamonds in which no evidence of the 5920 Å line is visible, our statement reads: "Nothing observed that, on the basis of past and continuing research, suggests other than natural color."

It is hoped that further research may make it possible to issue even more positive reports for these important stones.

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continued on page (117)

The Lapidary of the Learned King

By

JOHN E. KELLER, Ph.D.

Professor of Romance Languages, University of N. C. Chapel Hill, North Carolina

A few miles out of Madrid, on a barren hillside and surrounded by harsh and austere mountains, lies a building that contains one of the world's most fabulous libraries. The building is the *Escurial,* built by Philip II, a harsh and austere man. To this building King Philip brought many books that had been ransacked from the best monastic and cathedral libraries in the Iberian Peninsula or bought from the richest archives in Europe. Not even a great fire, which destroyed over 4000 books and manuscripts, and not even the Russians, who carried off other books and art treasures during the late Spanish civil war, could deplete the Escurial's supply of wonderful books. And among these books today is found the once celebrated, but now seldom read, work of Alfonso X el Sabio (the Learned), a book known as the *Lapidario.* This work on gems is not the only work patronized by the Learned King. In the Escurial are to be found the famous *Cantigas de Santa Maria* (Canticles of Holy Mary), the *Libro de Astronomia* (Book of Astronomy), as well as others. King Alfonso X was not known as the "Learned" for nothing. Few monarchs in any age, and none in the Middle Ages, were his equal as a scholar or as a patron of the arts and letters; none took such an interest in the laws and the sciences; none had such broad and careful treatises written on games like chess, dice and hunting.

In medieval times, lapidaries were much in vogue, for men in the East, as well as in Europe, set great store by the magical properties of precious stones. Doctors of medicine used such stones, whole or pulverized, as cures for any number of ailments, and generations of people, both men and women, carried gems as charms against misfortune and physical danger. King Alfonso's *Lapidario* is the most complete repository of this lore in existence. Scholars believe that this book, so carefully translated out of Arabic at the Learned King's court, was known outside of Spain. Sir John Mandeville, writing in fourteenth-century England

1.

Por que este nuestro libro sea mas paladino ⁊ se pueda meior entender. et sepan los que lo leyeren mas ayna las obras que en el son pora ayudar se dellas quando las ouieren mester ⁊ lo touieren guisado. pusiemos aqui en el comienço deste libro sus partes: ⁊ las obras de cada part de sennaladamente cada una por si: segund que dixieron ⁊ prouaron los sabios antigos. Et dexemos primeramente delas partes deste libro: que son onze partes

La primera part es de abolays que fabla delas ymagenes ⁊ de sus obras que se fazen enlas piedras por los grados delos doze signos. ⁊ a en ella trezientos ⁊ sessaenta capitulos.

Et la segunda es de amtim que fabla de otra manera de ymagenes que se fazen por los grados delos signos enlas piedras ⁊ con los metales bueltos en uno. Et a en ella: trezientos ⁊ sessaenta capitulos

Et la tercera es de pitagoras que fabla de otras maneras de figuras que suben en estos mismos grados que obran en las nacencias delos omnes. Et a en ella: trezientos ⁊ sessaenta capitulos

Et la quarta es de yluz que fabla delas ymagenes que se fazen en las piedras: segund las fazes delos signos. Et a en ella treynta ⁊ seys capitulos.

La quinta es de belyenus ⁊ de yluz que fabla de muchas maneras de ymagenes que se fazen en las piedras por las planetas quando son en sus dignidades ⁊ en sus horas. Et a en ella capitulos.

Et la sesta es de plinio ⁊ de belyenus ⁊ de otros sabios ⁊ fabla de ymagenes que se fazen en las piedras faziendo dellas sortijas. Et a en ella capitulos

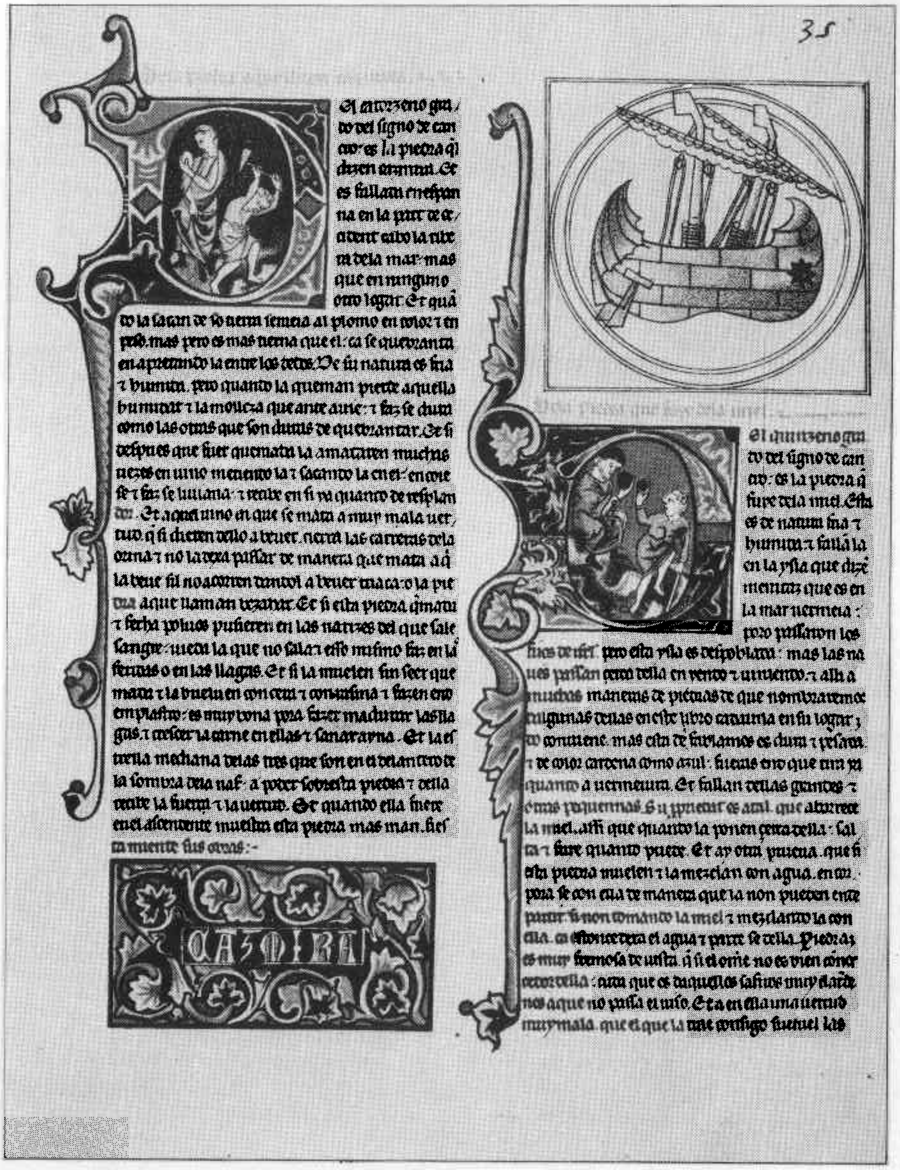
La .vij. es de utarit: ⁊ fabla de siete ymagenes que se fazen por las siete planetas: en siete piedras sennaladas ⁊ fazen se dellas sortijas. Et a en ella siete capitulos.

Et la ochaua es de rrgiel que fabla de .xxiiij. ymagenes que se deuen fazer en piedras sennaladas Et a en ella .xxiiij. capitulos.

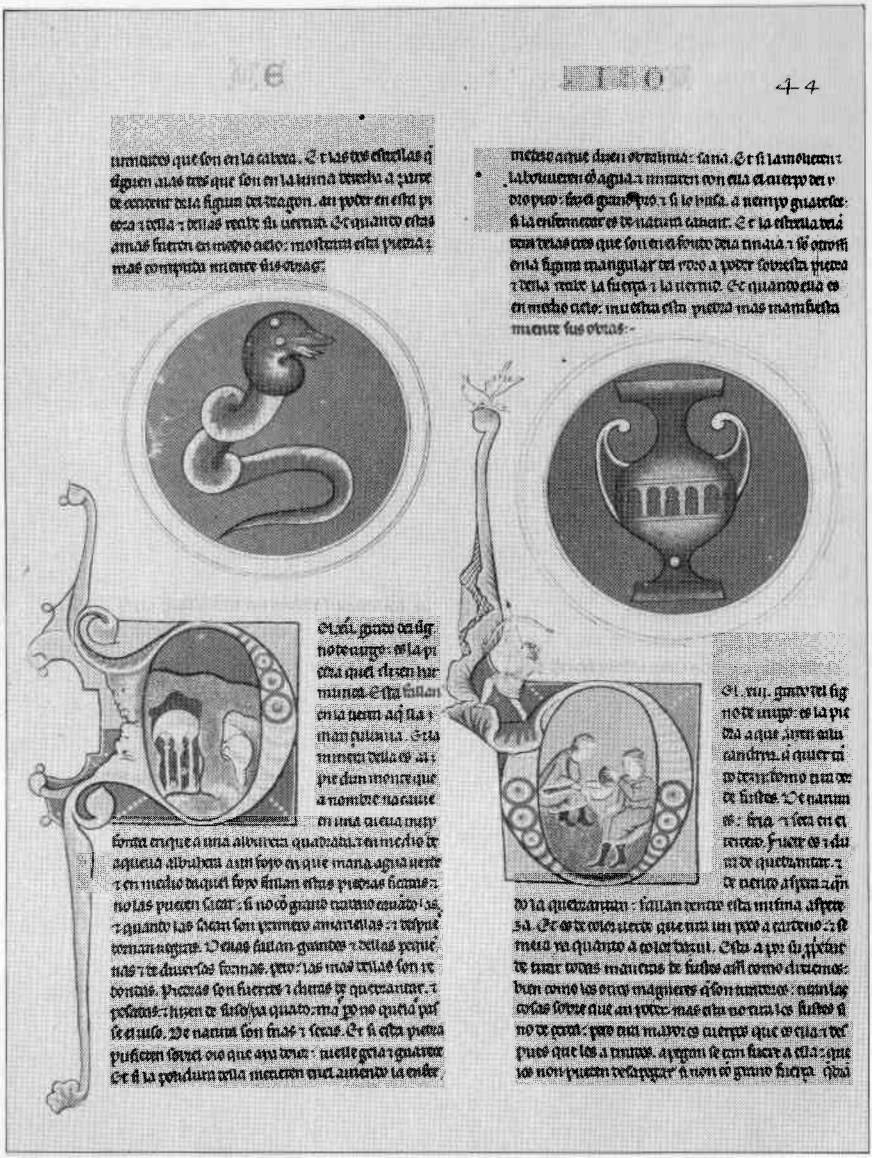
La .ix. es de yacoch que fabla delas aguas ⁊ delos lodos que son mester en esta obra delas piedras. Et a en ella siete capitulos.

Et la .x. es de aingue fabla de cuemo se

King Alfonso X and his Scribes *(page 1, reproduced from the Lapidario)*



Of the stone which they call cazura *(left column)*
Of the stone that flees from honey *(right column)*
(page 35, reproduced from the Lapidario)



Of the stone which they call harnumca *(left column)*
Of the stone which they call culucandria *(right column)*
(page 44, reproduced from the Lapidario)

Of the stone which appears in the sea *(left column)*
Of the stone which is named beyti *(right column)*
(page 89, reproduced from the Lapidario)

(but writing in French) of his travels, mentions the *Lapidario* as a book "with which many men are not acquainted," but other reports indicate that the *Lapidario* was well known and that many other books were based on it.

The copy in the Escurial is truly a wonderful piece of writing. It is a royal manuscript, and no expense was spared to make it a thing of great beauty. The best scribes — artists of calligraphy — penned it; the best professional illuminators illustrated it with some of the Middle Ages' finest art work, and the man who translated it from Arabic was certainly a scholar in two tongues and a person of extreme meticulousness. At the beginning of the index to the *Lapidario* there is an illumination in vivid colors representing the king and his sages and scholars. The black-letter text describes the book as having been translated into Castilian "from the books of the ancient philosophers" and transcribed in the Spanish Era 1314 (in our own computation of time, in the year 1276), the twenty-fifth year of the king's rule. It was transcribed at the command of "the much exalted and honored Don Alfonso, lover of sciences and learning, by the Grace of God, King of Castile and Leon, Toledo, Galicia, Seville, Cordova, Murcia, Jaen and Algarve."

When one considers the difficult times in which this king played an important role, it is surprising that he found the time to engage in so many learned and scholarly pursuits. An impoverished treasury and a nobility often in rebellion; attacks from Moorish Spain into his realms; civil war brought on by his own son, Sancho the Fierce; and a wife who was, to say the least, one of history's greatest shrews, should have left him no time and little money for the patronage of art and literature and science. Nevertheless, he managed to make his court the seat of Europe's greatest learning in the thirteenth century. To it flocked all "wise men," Catholics, Moors and Jews, to receive his help and support. He was very anxious to make Castillian a language of learning, and had most of the learning of the times translated into his native tongue; he was the first to command all public documents to be written in Spanish, when other nations were still using Latin; he had the Bible translated; he had the laws compiled into a codex that rates as one of the three most detailed and voluminous codices in the world (the Codex of Hammurabi and the Code of Justinian are the others); his astronomical tables were the only ones in general use in Europe until the sixteenth century; his *Cronica General* is one of the earliest and one of the largest of all national histories; and his *Canticles of Holy Mary* record the greatest number of Our Lady's miracles, replete with illuminations, musical notation, and the miracles written in verse.

The *Lapidario* is divided into twelve parts, in accordance with the twelve signs of the zodiac. At the beginning of each part there is an elaborate design, surrounded by its corresponding constellations, which are said to influence "all terrestrial bodies," for, according to the *Lapidario,* there is a mysterious waxing and waning of the virtues of stones and plants in accordance with the position of the stars.

This book of stones is divided into many short chapters. The numerous and colorful illustrations are interesting and informative as pictures of medieval life. Mere reproductions can hardly give an adequate idea of the startling beauty of these illuminated pages. There is a great richness of red, blue, green and yellow, blended delightfully and most skillfully shaded.

The names of the stones and gems are not all in Spanish or Latin. Some of them appear with the original Arabic names, and, since these were names in the thirteenth century, some have not even survived in Arabic and therefore cannot be identified today.

Three hundred and sixty stones and gems are listed, and many have such fantastic and

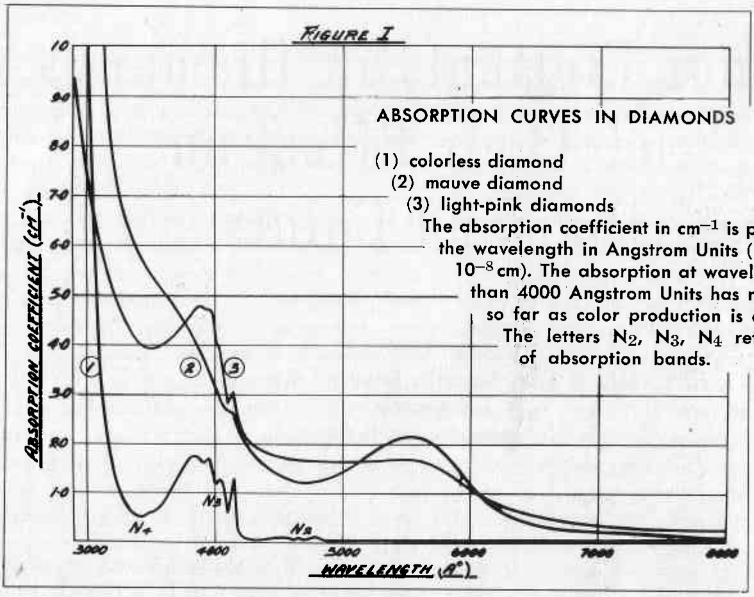
(continued on page 118)

Minor Elements in Diamonds and Their Effect on Diamond Colors

J. F. H. CUSTERS
(Director of Research, Diamond Research
Laboratory)
Johannesburg, South Africa

Diamonds as found in nature show a great variety of colors. Although the exact nature of the color centers in diamond crystals is still somewhat of a debatable point, it is certain that minor elements play a predominate role in most cases. Various impurity elements, of which aluminum, calcium, magnesium and silicon are quite common, happen to be dissolved in the diamond crystal lattice in much the same way as zinc may be dissolved in copper. By this we do not imply, however, that diamond crystallized from the molten state of carbon; neither is it alleged that the just-mentioned elements always act as chromophores in diamond.

Diamond colors resulting from the presence of minor elements are highly stable, even at temperatures up to about 500° C. This is understandable if it is realized that impurity atoms were trapped in the crystal lattice when the lattice was formed. This formation, as is now generally assumed, came about under quasi-equilibrium conditions of high temperature and high pressure. Since the dissolved elements have been subjected to these extreme conditions, we expect them to be hardly or not at all affected, either chemically or physically,. at the so much milder conditions of raising the temperature to 500° C. at ordinary pressure. Even a temperature of 1000° C. is mild when compared with the assumedly much higher temperature of diamond formation. Impurity-introduced diamond colors are stable at this fairly high temperature as well, but a quite drastic and purely physical phenomenon takes place even at temperatures lower than 1000° C. The diamond crystal is transformed into graphite, an altogether different allotropic crystal modification. The activation energy at this temperature is, still too small for any chemical reaction to take place involving the minor elements present and in the absence of air. Heating a diamond to 500° C. is actually a simple method to verify whether the color, if present at all, was introduced after the diamond was crystallized. If the color has not changed after the diamond is cooled down again to room temperature, it may be asumed that minor elements are responsible for its color. If, on the other hand, the color does change, it is highly probable that the color centers, whatever they may be, were introduced at very much less severe conditions than those at which diamonds were formed in nature.



ABSORPTION CURVES IN DIAMONDS

(1) colorless diamond
(2) mauve diamond
(3) light-pink diamonds

The absorption coefficient in cm^{-1} is plotted against the wavelength in Angstrom Units (1 Angstrom = 10^{-8} cm). The absorption at wavelengths shorter than 4000 Angstrom Units has no significance so far as color production is concerned. The letters N_2, N_3, N_4 refer to groups of absorption bands.

Two types of diamond colors are known to change on moderate heating. One color is introduced artificially either by bombardment with neutrons from nuclear reactor with electrons from a high-voltage electron source, or by irridiation with sufficiently energetic gamma rays. The resulting color is green, blue and greenish blue, respectively, and all of these colors turn into a pale brown or yellow when heating the artificialy colored diamonds to 450° C. A representative of the other type is a natural green diamond frequently found in Sierra Leone. It shows the same bottle-green color as a neutron-bombarded diamond, and it will also turn light brown on raising its temperature sufficiently high. Its green color can be explained by assuming that the diamond has been in contact with a radioactive substance (such as uranium) dispersed in the rock in which the diamond was embedded or present in the alluvial ground in which diamonds occur[1].

Such diamond colors that change on heating the crystal are not due to minor elements, since it is impossible for these elements to diffuse out of the crystal lattice during the short period that heat is applied. Neither can a color change be explained by assuming that the configuration around the impurity atoms is altered on heating, or that these atoms might take up new equilibrium positions which could cause the electronic energy levels and thus the color to change. The reason for this is that the minor-element atoms already occupied the most stable equilibrium positions when the diamond was crystallized.

It is now well-known that the just-mentioned artificial coloration is due to a certain fraction of the carbon atoms themselves being displaced from their original positions, and this so-called radiation damage may be more or less severe depending on the type of projectile and on its energy. It is assumed that a fast neutron penetrating a diamond crystal can raise its temperature locally to extremely high values, as if the diamond, in a space of the dimensions of a few Angstrom units, was made to boil for a very short time, A somewhat chaotic atom

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[1] The characteristic bottle-green color of Sierra Leone diamonds might point to the presence of uranium compounds somewhere near the spots where diamonds are found.

arrangement is thus created under conditions that are far from equilibrium. This chaos can be undone only partly by subsequent heating, and the result is a pale-brown diamond.

Of course, it can not be excluded that some of the impurity elements will be transmuted to other elements when bombarding the diamond with neutrons or other atomic projectiles. Such nuclear reactions are, however, entirely overshadowed by the above-mentioned carbon-atom displacement. It should be remembered that the minor-element concentrations are small and very seldom larger than 0.1% by weight.

An extensive program of research on the subject of artificial diamond coloration and on the effect of heat on such diamonds has been carried out at the University of Reading. The results of this investigation have been published by Clark, Ditchburn and Dyer[1-2].

The Diamond Research Laboratory has been engaged for quite some time in trying to establish a relation between the natural color of diamonds and their impurity-element content. A fairly comprehensive paper on the subject of minor-element content has been published by Raal in the American Mineralogist, 1957[3]. It was found that a relation as mentioned above could not be clearly established, although there was a tendency for some elements such as iron and copper to be present in colored diamonds. One of the difficulties in relating a certain minor element to a color is that normally more than one element is found. Another difficulty is that the light-absorption curves of diamonds, as determined by means of an absorption spectrophotometer have, even at low temperature, no well-defined maxima that can be ascribed to certain impurity elements. It is true that Type I diamonds in particular show sharp absorption maxima, as is evident from the paper by Clark, Ditchburn and Dyer[1], but these maxima are due to the electronic and vibrational energy levels of the diamond crystal itself, and definitely not to minor elements. Moreover, they occur for the greater part in the ultraviolet, and thus cannot greatly contribute to color production.

For the first time, however, we have established that the color of mauve and pink diamonds is most probably due to one element only; namely, manganese. A white, a strongly mauve colored and a light-pink diamond, respectively, were carefully examined with respect to both their minor-element content and their absorption spectra. A new absorption band was found to be present in all pink and mauve diamonds thus far examined. The maximum of this broad band was situated at 550 millimicrons (as shown in *Figure 1)* for the pink and mauve stone, respectively. Some brown diamonds also show this band apart from a fairly strong general absorption in the violet part of the spectrum, which gives the stone its predominantely brown color.

It will be seen that the maximum for the mauve diamond is much more pronounced than that of the pale one, as one would expect, since the first-mentioned color was much stronger than the pink.

The next step was to analyze the diamonds for minor-element contamination, and it was found by Raal and his coworkers that manganese was present besides the elements silicon, calcium, mangnesium and aluminum, which are common to nearly all diamonds. The analysis was semiquantitative, resulting in a larger manganese concentration in the deeper colored stones. It is thus highly probable that the color of mauve and pink diamonds is due to manganese.

In a few cases of pale-pink diamonds, the persistent spectral lines of manganese could not be detected. This may have been due to the manganese concentration being smaller than about 10 parts per million, in which case it would be very difficult to establish the presence of these lines: Their appearance depends also to some extent on the other minor elements present, since these will affect the excitation in the high-temperature electrical arc of the element to be analyzed.

We can ask ourselves in what form the manganese is present in the diamond crystal. It may be assumed that it occurs in the form of an ion, either as the trivalent ion Mn^{3+}, or as the divalent ion Mn^{2+}. The absorption of the ion will depend on its atomic surroundings. In diamond it is surrounded by covalent bonded carbon atoms, which may be considered as C^{4+} ions. Now it is known from extensive investigations on colored glasses[4] that Mn^{3+} ions give a strong purple color, whereas Mn^{2} results only in weak yellow and pale-brown colors. The absorption maximum of the Mn^{3+} ion lies between 470 and 520 millimicron, depending on the base glass. We are thus led to suggest that the manganic ion Mn^{3+} is the coloring agent in the pink and mauve diamonds. Since in diamond the Mn^{3+} ion is surrounded by C^{4+} ions, as opposed to O^{2-} ions in the case of glass, the maximum of its absorption would tend to shift somewhat towards longer wavelengths compared with its position in glasses.

Finally, we should mention the peculiar steel-blue color shown by nearly all semiconducting diamonds that have been classified as Type IIb[5]. Some of these Type IIb's are among the purest diamonds ever analyzed; they are generally purer than Type IIa diamonds, which are again purer than Type I's. We know that the semiconductivity and the color are related somehow, and we never came across an exception to the rule that all natural blue diamonds are semiconducting. On the other hand, however, we found a few semiconducting diamonds that were pale brown.

The only minor elements found spectrographically in natural blue diamonds were aluminum, magnesium and silicon, in very low concentrations. We do not think that either one of these elements is the coloring agent, for diamonds that were found to contain very much more of these elements (in one case 50 parts per million of silicon) were not blue. Neither could silicon or magnesium be the cause of the semiconductivity of Type IIb diamonds, since we would expect only elements of which the valency is 3 or 5 to be responsible for this electrical phenomenon. The only possibility left would be aluminum, which has a valency 3, and could thus act as an acceptor atom. But again we would then ask why so many diamonds containing a high aluminum content are colorless.

It is obvious from the above short survey that we do not know nearly all of the aspects of this interesting subject of minor-element content in diamonds. It is even possible, in so far as semiconductivity is concerned, that the method of spectrographic analysis cannot give the answer, since its analysis capacity does not go below a concentration of one part per million. We know from the elements silicon and germanium that they can be made into semiconductors by the introduction of foreign atoms in concentration of one part per ten million, or even less. The author also feels that the blue color of the great majority of semiconducting diamonds might not be due to an impurity element but to some other type of lattice defect that would also be responsible for the electrical properties of this type of diamond crystal.

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A New Imitation Turquois from Germany

By

ROBERT WEBSTER, F.G.A.

Turquois, with its beautiful blue color, has been prized as a medium of adornment since early times, and was so used by many of the ancient civilizations of both the Old World and the New. Also, it was one of the earliest, if not the earliest, gemstones to be imitated.

A. Lucas *(1)* mentions several turquois-colored objects found during archaelogical excavations in Egypt. In general, these consisted of frit composed of crystalline compound of silica (quartz pebbles), copper (malachite, for example) and calcium (natron, for example). Another type was a glazed siliceous ware. Objects of glass, colored turquois-blue with copper compounds, have been discovered at Thebes, and glass pieces colored by cobalt were found in the tomb of Tut-Ankhamen (or Tutenkhamon).

So much for early history. In more recent times, apart from colored and opacified glass, stained chalcedony, and glazed chinaware, the main imitations that most nearly resemble turquois are finely ground and suitably colored powders having a composition near that of turquois. These are bonded by some form of cement or consolidated by pressure. Such an imitation is the so-called "Viennese turquois," which, according to Koch/Dudich *(2)*, is composed of 0.5 parts of malachite, six parts of aluminum hydroxide, and two parts of concentrated phosphoric acid. These constituents, after being thoroughly mixed and ground to a fine powder, are heated to over 100° C. and compressed with great force. The finished product is said to have a similar specific gravity, hardness and chemical composition as the natural turquois. G. F. Herbert Smith *(3)* mentions an imitation with similar characteristics that had been made by pressing together a precipitate of aluminum phosphate colored blue with copper oleate.

For purposes of comparison with the new German material, to be discussed later, the results of some tests on a "Viennese turquois" type of material may, with advantage, be given. Chemical tests showed the presence of copper and phosphorus, and when the material was brought into solution of acids, the addition of ammonia produced a flocculent precipitate indicating the presence of aluminum. The refractive index was found to be about 1.45. The material is much more porous than true turquois, and this is made very evident when a density determination of the material is made. A "snap" density determination will give a value of 2.4, which goes up to as much as 2.7 with well-soaked material.

The material does not exhibit luminescence and does not decrepitate when heated in a flame. A spot of concentrated hydrochloric acid when placed on the surface turned to a strong yellow-green color that, when absorbed on a filter paper, produced a yellow stain. Apart from the acid destroying the polish, the specimen itself suffered little harm. Hydrochloric acid does not have this effect when placed on real turquois, but does behave similarly with the natural copper minerals, malachite and chrysocolla.

Since the end of World War II, other types of artificially produced turquois imitations have been encountered, such as the "reconstituted turquois" of good blue color with a spider-like network of dark-brown lines mentioned by Liddicoat *(4)*. Another so-called "synthetic turquois," said to have emanated from Miami, Arizona, was reported on by Webster *(5)* and Lee *(6)*, in which the bonding of the grains was found to be a styrenated alkyd. The earlier type of this imitation showed its hardness to be about 2¾ (Mohs' scale), the specific gravity to be 1.85, and the refractive index about 1.56. A later and more compact type had a density of 2.39. In these plastic-bonded types the porosity was much less apparent, but, like the "Viennese turquois" mentioned above, a spot of hydrochloric acid turned to a yellow-green when applied to the surface of the specimen.

The new German imitation has a very good turquois color, is veined with a dark-colored "matrix," and takes an excellent polish.

The composition of this new material has been well covered by the investigations of Steinwehr *(7)*, who, by X-ray diffraction methods, categorically proved that the material was not turquois, that the diffraction picture obtained gave an indication that the substance was a mixture of *bayerite* and a copper phosphate $[Cu_3 (PO_4)_2 . 30H]$, and that the "matrix" was probably due to some amorphous iron compound.

Bayerite, which is an important by-product of the clay and aluminum industries, has a composition chemically the same as *gibbsite (hydrargillite)*, which is $AL (OH)_3$, or may be expressed as $AL_2O_3 3H_2O$.

A qualitative chemical test, carried out by C. H. Schmitt, showed the presence of aluminum, copper and phosphate, with a little iron. This agrees entirely with the X-ray results.

Experiments by the writer on a sample of this material proved, if proof is needed, that the substance contained phosphorus, copper, aluminum and possibly iron, the test by potassium ferrocyanide for this element being considerably masked because of the presence of much copper. The material, when heated, blackens but does not decrepitate like the true turquois. A thinnish section examined under the microscope showed the material to have a granular nature as though a fine-grained powder had been consolidated by pressure. No proof of a plastic binding could be found.

The material could be just scratched by fluorspar; therefore, the hardness for this imitation turquois is about 3¾ on Mohs' scale. The refractive index, as far as could be determined on a refractometer, was a vague reading at about 1.55. The material is porous, making the determination of the specific gravity unsatisfactory. A "snap" determination gave values as low as 2.33, but after allowing pieces to soak for some time, values near 2.40 were obtained.

The absorption spectrum of true turquois (lines in the blue, particularly one at 4300

Å), does not appear in the imitation. Indeed, the turquois lines have never been seen in any imitation of turquois and are therefore diagnostic. Under the long-wave ultraviolet light, the new imitation shows a bluish glow pin-pointed with bright-blue spots, and exhibits a similar but weaker effect under the short-wave lamp. Like so many of the turquois imitations that owe their makeup, in part, to natural copper minerals or copper compounds, a yellowish-green color is induced in a spot of hydrochloric acid placed on the surface.

This new German imitation turquois is undeniably attractive and makes a good imitation. However, it can be identified without difficulty because of its unnatural-looking "matrix" veins, its low hardness, and its refractive index. The acid test, if used on an inconspicuous part of the base of a specimen, leaves little or no damage and will easily prove whether it is genuine or imitation.

In conclusion, thanks must be given to G. O. Wild of Idar-Oberstein who provided the specimen of this new imitation turquois.

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THE LAPIDARY OF THE LEARNED KING

extraordinary properties that one begins to think of fairy tales and the most exotic tales out of the mystic East. There is the "stone of sleep," which is red, transparent, difficult to shatter, impervious to fire, and glows at night so that "those who live on the Isle of Alicuas, near the Sea of Alcuzun (the Red Sea), on whose shores the stone is found, when they see a light shining at their feet in the night, stoop and pick up the stone of sleep." This stone is prized by physicians and surgeons because it brings a calm and restful slumber, after which the patient awakens clear of mind and refreshed in body; therefore, it is "much used for the wounded so that for awhile, they may forget all pain." This powerful stone, when used as medicine, must be handled with great caution and taken only in small quantities. One single drachma is enough to bring on uninterrupted sleep for three whole days and three whole nights, and even then. if the sleeper is not awakened by one who understands the virtue of the stone of sleep and knows how to give the sleeper his full release, he will turn over and sleep again.

One chapter is labeled "About the Stone Which is Called the Diamond." It reads as follows: "The Sigh of Taurus (the Bull) is the second among the twelve signs of the Zodiac we have mentioned. It is divided into thirty degrees and a kindred stone corresponds to each degree; and it is from these that it holds its virtues, as will be explained in the following. The stone called *Mex* in Arabic and diamond in Latin is the first of these stones. By nature, this stone is cold and dry in the 4th degree. It originates in the river called Barabicen, which flows across the land called Boracim. However, it becomes stone (it crystalizes) only in the land that enjoys six months of perpetual daylight and six months of continuous darkness. No man has ever visited the land where this river originates, for there are many serpents and other beasts dangerous in many ways, and there are also vipers that kill a man by merely looking at him. These are the reasons that men do not dare to go to that place.

"When the river is in flood, numerous small tributaries and canals branch off from it and carry the stones along. There again, as where the river has its origin, there are some very large and also very small stones. Some are of a transparent dusky hue, reminding one of brass; others are light green or light yellow, but the best of them look like clear glass.

"There are men who manufacture paste diamonds. In order to find out which is real and which is false, or paste, it is best to put the stones in fire, when the paste stone will melt. But not even fire is able to destroy the true diamond, which is able to split any other stone by drilling or by cutting, while no other stone is able to crack it. Besides, when the diamond carries other stones along it grinds them. However, there is a kind of lead, called *azrob* in Arabic and oxyde of tin in Latin, that cracks the diamond in the following way: the stone should be inclosed completely in oxyde of tin, and then by hitting it with a hammer it cracks immediately. After a crack has been produced, the stone is put into a mortar of the same metal and pounded until it is pulverized. If a little of this powder is mixed with some other matter and given to a man suffering from a stone in the bladder, the stone is immediately destroyed and the patient is cured. Some people take a small splinter of diamond and fix it on a thin piece of iron and apply it to a man who suffers from a stone in the genital parts in such a way that the diamond is in contact with the diseased part. The stone straightway is broken up. But this should be applied only in cases where recovery of the patient seems rather doubtful.

"Those who drill or cut other stones use small, light, and very sharp-edged pieces of diamond fixed to a stiletto of silver or copper and drill or cut other stones with it. The diamond is also very poisonous on account of the poisonous animals which breed where the stone is found. As the stones are always of a square shape and have sharp edges, they scrape against these poisonous creatures and thus are contaminated with their venom. Therefore, when one takes the diamond into his mouth and holds it there for awhile it ruins his teeth and they fall out. It does even worse harm: if one takes the weight of a drachma (a small coin) and grinds it with the help of lead, as above mentioned, and gives it to a man to drink, that man will die.

"We have mentioned previously that the diamond is of a cold and dry nature and that its powers are such that those who carry it are cured immediately, move swiftly, and are able to do anything that demands bravery and daring. The fiery star, which is located in the right muscle of the arm of the one who looks up with attention, and the other one, which is just above the head of the same figure, hold the power over this stone and it is from these that it gets its virtue. When these stars are in the mid-heaven, the stone is the most powerful.

"The stone that is called diamond belongs to the third phase of the sign of Gemini. It is the same of which I have spoken when treating the first degree of the sign of Taurus. Its powers are such that the man who carries it will be very fond of his home and will be very lucky in it. People will speak kindly of him. The same things, but in a more restricted way, apply also to Saturn, in this phase and in its ascendant, and in its time and in the triple aspect, or when observed together with the moon. The powers of the figure armed with the bow, the quiver and the arrows descends on this stone."

There is a stone called "the stone that flies from wine." The *Lapidario* gives it no other name, but Ptolemy is quoted as an authority about it, and in the Middle Ages Ptolemy was considered a great authority on many things. His word was good enough. He is quoted as saying that the stone of sleep comes from "an island named Cacuac in the Sea of Alcuzun, where strange trees grow that bear fruits shaped like the figures of women hanging by the hair of their heads." The stone is very precious for its clearness and beauty, and kings place it in their crowns, and great noblemen use it as their adornment. The chief feature, however, is its abhorrence of wine which is so great that if it is placed in close proximity to any alcoholic liquid, the stone will "jump away." And, continues the *Lapidario,* "yet another marvel is in this stone: when it is burned, its ashes will retain the beautiful colors of the stone, and will have the virtue that if they are placed in a barrel of wine, the wine will turn to a liquid the color of clear water, no matter how strong a wine it was."

Still one other property is that it protects the one who carries it or wears it from giving rein to devilish imagination and keeps him from fearing the darkness.

The emerald has a great store of lore in its history. It, like many other jewels, was said to possess great virtue. The *Lapidario* says that it is "a remedy for all mortal poisons and for wounds and the bites of poisonous beasts. Take one drachma and pulverize it and give it in wine or water to a poisoned man, and he will not die, nor lose his hair, nor will his skin peel off."

However, there are certain adverse positions of the stars that have so deadly an influence upon the emerald that he who wears it at such times "will have his senses clouded and he will understand nothing until he removes the gem from the decorations of his person."

And if one has the emerald engraved with the figure of a man or of a lion, he may travel from court to court with no fear of harm, knowing full well that he will be received by princes and great men.

Some of these beliefs lasted into the Renaissance, and indeed, even today folklorists find them among the people of many areas of the earth. Remodeus had earlier than the Renaissance praised the mystic powers of jewels, stating that "they adorn kings' crowns, grace the fingers of men and women, make household treasures more bright, defend men from enchantments, keep them healthy, cure diseases, and drive off grief and worry." Such depression the *Lapidario* likewise says are to be healed by stones.

In the Renaissance, too, to return to the stones graven with figures of men and beasts, Benevenuto Cellini, the great silversmith and jeweler, set jewels engraved into fine settings as talismans.

The emerald had power against evil demons and spirits, according to the *Lapidario,* and "for this reason and due to its beautiful green hue, it is greatly loved by men." Besides, "under the influence of certain planets it makes its owner loved by old people, by writers and sheriffs, and the emerald's possessor can do as he will with these people."

Before taking up the ruby, let us look at another of the stones difficult to identify. This is called "the stone of the hermit." It is found "in the sea called Alcuzun, over which Moses led the Israelites to pass. Men use it in strings of beads or set into rings, for when they wear it they are able to escape the wiles of women. Therefore, wise men of olden times gave it to hermits and religious men and to all who have taken vows of celibacy."

But women were given a chance after all. A stone known at *Tacitz* (also not identified) stands them in good stead. It is "a stone resembling crystal, although not quite so clear, and it has a dark center in the form of a shadowy line. The woman who wears it can enslave all men at will." The Learned King does not tell what would happen if a beautiful lady equipped with a fine *Tacitz* set out to win a fellow protected by a string of stones of the hermit.

The Lapidario names the ruby as the *Bezebekaury,* but it has been identified with the ruby. "In Chaldean," relates the Learned King's book, "the name means 'remover of sorrower and giver of joy'," because the stone has the power of doing these things. He who carries it can drive away any kind of sadness whatever. It is found in Zulum, near the town of Eniz (wherever this is). It is of great beauty and is colored either red or green, and every stone is quite clear and of great brilliance. A famous history of the ancient world (Rawlinson) says that green rubies were found in Bactria and red ones in Caria. Scholars think that these are the Bezebekaury.

Such stones, "when reduced to powder, are mixed with remedies for weakness of the heart," and can be used effectively to cure sores and break blood clots.

There is a stone "that turns water into blood," and one that "turns gold into silver," and crystal breaks off drought and attracts rain to stricken areas. Cornelian is good for lawyers, for "it strengthens the voice and gives them power to plead cases fearlessly." But they must not wear it during the ascendancy of certain stars and planets, lest it make them sad and discouraged.

Then there was the "stone of the three colors," which was pulverized and mixed with the flowers of the privet to produce a jet-black hair dye that would not fade. Another was *stopaza,* which caught snakes and other reptiles that were believed to stick to it and thus were caught. The *Dichmid,* which was green jasper, under certain planetary conditions causes strife. The *Zayetanizes* made the wearer immune to the bites of beetles and insects. There was a stone "that flies away from honey," "the stone that rises in the sea when the planet Mercury rises," and the "stone that attracts gold as the magnet attracts iron."

These are only a fraction of the three hundred and sixty stones treated. Indeed, there is more fancy — and probably more fact — about the Middle Ages in King Alfonso's *Lapidario* than almost any other book from those times. An investigation of them all would be a fruitful study. As yet, however, no edition exists, except the one that is a photographic copy of the original. Therefore, the ancient Gothic hand must be understood to read it and the vocabulary of a by-gone century.

The exact debt of gemologists and those who deal in precious stones cannot at present be traced in the *Lapidario;* but inasmuch as this book of the Learned King first placed eastern gem lore at the disposal of medieval Europeans, that debt must be great. It would require the combined efforts and investigation of students of Medieval Spanish, philology, folklore, Arabic, Greek, astrology and astronomy, medicine, and chemistry to fathom the Lapidario's mystery.

An edition into the lettering of our own time is now in progress and should be in print in a year or so. A vocabulary study is also underway. As time goes on, more and more will be uncovered about one of the most influential books, and as yet one of the least known books of the Middle Ages.

Book Reviews

GEM MATERIALS DATA BOOK, compiled by Charles J. Parsons, C. G., F. G. A., and Edward J. Soukup, G.G., F.G.A. Published by Gems & Minerals Magazine, P.O. Box 687, Mentone, California. Price $2 (paper bound).

The Gem Materials Data Book has been prepared to provide a complete source for the property values of all gem materials. The general tables carry a master list of gem names, with cross references to the species of which the named material is a variety. Under the species, the information given includes chemical composition, color transparency, refractive index, birefringence, crystal system habit, optic character and sign, dispersion, pleochroism, specific gravity, hardness, characteristic inclusions, cleavage, fracture, remarks, and special tests or features. In addition, separate tables for refractive index, dispersion, color, specific gravity, hardness, toughness, and pleochroism are included. Also included are pronunciations of common gem names and a list of misleading names, together with the correct term for each.

The effort that went into this compilation by the two gem hobbyists (and GIA graduates) was obviously enormous. An examination of the master tables suggests that they would have been less unwieldly if the multiplicity of misleading terms, variety names and some of the more obscure materials had been treated in a separate section. For example, such terms as "adamantine spar," "African jade," alalite, the plagioclase feldspars, asparagus stone, australite, etc., make the table so bulky that its use is limited unnecessarily. Those who will find this book most useful are already cognizant of the variety of names and misleading terms, so their inclusion in this manner seems unnecessary. Perhaps a separate table for the more rarely encountered materials would have kept the master table in a more reasonable size.

However, beyond minor questions with a few of the property figures given and some of the comments, the *Gem Materials Data Book* is one that gem hobbyists, among jewelers and laymen alike, will find both interesting and useful.

ROCKS AND MINERALS, by Herbert Zim and Paul Shaffer, with illustrations by Raymond Perlman. A Golden Nature Guide

Book Reviews

book published by Simon & Schuster, New York. Paper bound $1, cloth $2.50.

Herbert Zim, a professor of education at the University of Illinois, has written several books in this series in collaboration with professors in the field the book covers. They are characterized by the beauty and profusion of the illustrations. *Rocks & Minerals* averages two or more full-color drawings or photographs on each page.

The text is authentic and well written. All in all, the book makes a valuable and decorative addition to any library.

GEM STONES OF THE UNITED STATES, an abstract by Dorothy M. Schlagel. Geological Survey bulletin No. 1042-G. 253 pages. Published by the United States Government Printing Office, Washington, D. C., 1957. For sale by the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. Price 25 cents (paper bound).

The aim of the author is to furnish the mineral collector or gem hobbyist with some of the important information available on the gemstones of the United States. About fifty of the major gemstones and many of the rare ones are described in this report. A geographic distribution of deposits of the principle gemstones in a 20-page table lists them by state, county, and locality. Other chapters discuss physical and optical properties, correct nomenclature, synthetics, imitations, assembled stones, gemstones in which the alteration of color is possible, and geologic occurrences.

The gemstones found in the United States are also described individually, including tables of properties, occurrences, and localities. A list of the journals featuring gemstones and a selected biography is provided.

Forty-two of the States are listed as having deposits of gem minerals, California having the largest variety and greater number of deposits.

Dana's "Textbook of Mineralogy" was used as reference for the chemical formulas.

Gemological Digests

RARE MINERAL FOUND IN CALIFORNIA

(from Mineral Information Service, Division of Mines, San Francisco)

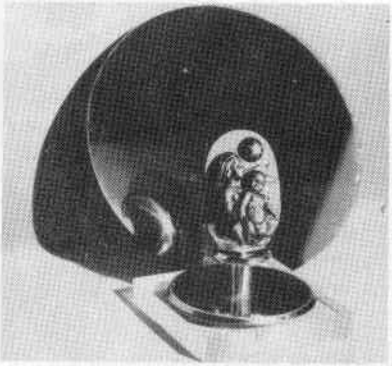
Hambergite, a rare beryllium borate having the formula $Be_2(OH)BO_3$ has been discovered in San Diego County, California.

The mineral is extremely uncommon; no other occurrence in the Western Hemisphere is known. Specimens have come from Scandinavia, Madagascar and India.

The new source for this rare material was found at the workings of the Little Three Mine, near Ramona. (Winter, 1956-57, issue of GEMS & GEMOLOGY carried an article entitled "Recent Gem Mining in Ramona, San Diego County," in which the Little Three Mine was discussed.) Captain John Sinkankas, U.S.N., the author of the above-mentioned article, was the discoverer. Since the original finding of the crystals of hambergite by Sinkankas, the owner of the mine; Louis B. Spaulding, has found others by screening the material from the dump.

A small area at the top of the open-cut workings was the site of the discovery. Apparently, it was the floor of a pocket that had been excavated in the early days of mining in the county. According to Captain Sinkankas, ". . . because of the surrounding terrain, the pocket debris remained in place and the hambergite, which superficially looks like feldspar, was left behind unrecognized. The crystals range in size from mere slivers to about two inches in length. They resemble the Madagascar hambergite in most essentials; except for clarity. Only a few slivers were found that showed transparent areas; the majority were almost pure white as the result of numerous veils, or inclusions (?). The crystals were either attached on one end or doubly terminated. Some were found perfectly formed except that invariably the sides of the prisms were striated with oscillatory growth, very much like tourmaline. Associated minerals were topaz, smoky quartz, feldspar, and lepidolite."

"MADONNA OF THE STAR," A CREATION IN STAR SAPPHIRE

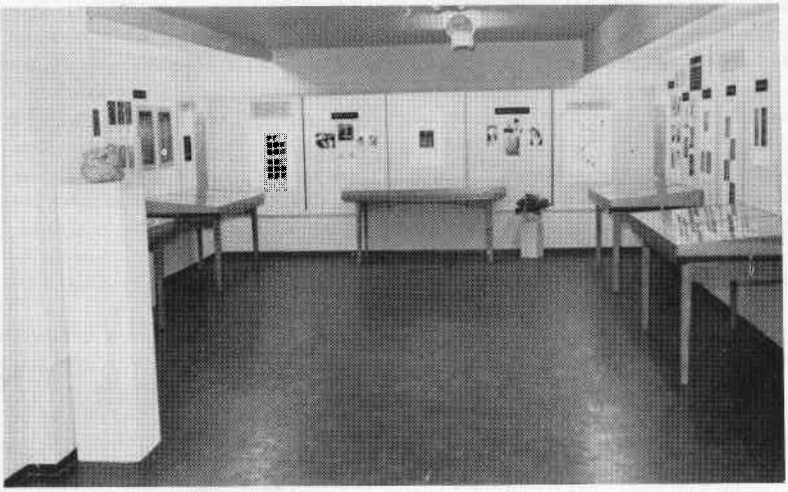


Madonna of the Star, a unique, carved 545-carat star sapphire, believed to be the only one of its kind in the world, has been fashioned by Harry Derian (Kazanjian Brothers, Los Angeles), the artist who carved the heads of three Presidents in sapphire. James and Harry Kazanjian, gem importers, who are the owners and creators of the Madonna, plan to mount the carving in a small crystal or in alabaster, setting it so that it has the appearance of a shrine.

The Director of the County Museum, Exposition Park, Los Angeles, has announced a continuation of the showing of the statue, due to the extreme interest it has aroused.

Five months of painstaking work were spent by Mr. Derian in carving the Madonna from the 1100-carat star sapphire, after the basic designing was finished. The stone, which has a decided chatoyancy, came from Queensland, Australia.

Gemological Digests



SWEDEN HAS GEMSTONE AND PEARL EXHIBITION

A gemstone and pearl exhibition, the first of its kind to take place in Sweden, was recently arranged by Thure Detter, jeweler of Malmo, Sweden, in conjunction with the newspaper, *Sydsvenska Dagbladet.* The exhibition, which was held during the latter part of December, 1957, and the first week in January, 1958 was received with great enthusiasm by thousands of interested persons who viewed the displays. One of the most enthusiastic was S. Hjelmqvist, Professor of Geology, University of Lund, who was very much impressed by the exhibition and who felt the exhibition furnished valuable publicity for both gemstones and pearls.

Thure Detter discussing diamonds at his exhibition

Gemological Digests

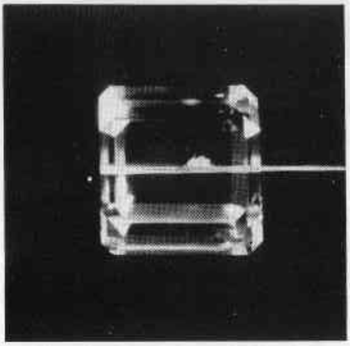


Figure 1

NATIONAL BUREAU OF STANDARDS USES A FLAWLESS TYPE II DIAMOND IN EXPERIMENTS

(from the NBS Standard. Official Bulletin)

The synthesis of inorganic crystals under conditions of high pressures and temperatures provides an interesting and most valuable program for the Constitution and Microstructure Section of the Mineral Products Division of the National Bureau of Standards. The objectives of this program are the synthesis of crystals of high purity and the precise measurement of their properties. Then, by submitting one element for another in a given crystal, studies are made on some of the fundamental property changes that may occur, such as changes in the optical, thermal, electrical, and elastic constants.

An unusual piece of equipment used in this work is a 7½-carat flawless diamond that was confiscated from a smuggler by the U. S. Customs and later turned over to the National Bureau of Standards by the General Services Administration. This diamond, a rare type II that is transparent in the infrared region of the spectrum, serves as one of the many pressure chambers used in studies to determine what happens to materials under great heat and stress.

The original emerald-cut diamond was modified into a pressure cell by drilling a hole of 0.015 inches in diameter through its center *(see Figure 1)*. Two tiny pistons of hard tool steel that closely fit the hole are inserted, one from each end, with the sample to be tested between them. The diamond containing the sample under pressure is then mounted in an infrared beam, where it is observed.

The results of these studies may well lead to a better understanding of the internal structural changes that take place in materials that are subjected to extreme pressures. It is quite possible that a few of these structural changes may find practictal application as secondary pressure standards, which are in great demand by workers in the field.

Mother Nature's laboratory deep in the earth, where immense pressures and temperatures exist, undoubtedly produces materials that are unknown to man. But, at the present time, since it is impractical to descend 250 miles into the earth, these conditions can be reproduced in the laboratory on a small scale, thus providing another means for studying crystals. Equipment required to produce such conditions consists of tough steel bombs and opposing pistons of special alloys placed in hydraulic presses. Pressures as high as one million pounds per square inch and temperatures up to 1500 degrees centigrade can be obtained with this equipment. Obviously, pressures and temperatures of this magnitude may become extremely dangerous. Consequently, safety precautions must be taken to protect personnel. All experiments are therefore conducted behind a steel barricade in an isolated building.

Contributors in This Issue

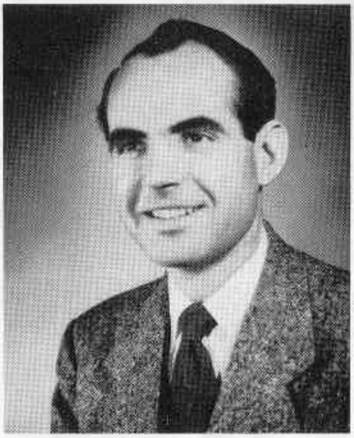
John Esten Keller, Ph. D., Department of Romance Languages, University of North Carolina, Chapel Hill, teaches all levels of Spanish but specializes in the Graduate School, teaching medieval Spanish language and literature. He has lectured on King Alfonso's works, both in this country and abroad. In the Spring of 1957, he lectured at the universities in Seville, Madrid, Coimbra, London, Oxford, Glasgow, Sheffield, Nottingham and Manchester.

Professor Keller also teaches folklore and comparative literature. These curricula, together with medieval Spanish, whetted his interest in gems and gemology, especially in medieval Spain, with the *Lapidary of the Learned King* as the focal point of his studies. He is presently preparing an edition of the *Lapidario* (only the photographic edition exists at the present time and is, of course, as difficult to read as the original manuscript, except to paleographers). Once such an edition has been made, he plans to translate it into English. Professor Keller feels the store of medieval gem lore that will be made available should be of interest to the present-day gemological student.

Professor Keller's contributions to dictionaries, his directions for dissertations, and his books on Romance language and literature are too numerous to mention, individually, in this short biographical sketch. His article *The Lapidary of the Learned King* appears in this issue on page

Robert Webster, F.G.A., is well known to gemologists in this country and abroad, and is associated with B. W. Anderson, Director of the Precious Stone Laboratory of the London Chamber of Commerce, London. Gemologists and students of this country know him well for his excellent *Gemmologists Compendium* and his earlier book *Practical Gemmology.* He has been connected with the jewelry industry in England since 1914, with time out for service in World War I. He was awarded the Fellowship Diploma of the Gemmological Association of Great Britain in 1934, and is one of the few to have received the Research Diploma awarded by that organization.

Contributors in This Issue



Jan F. H. Custers, Ph.D., was born at Eindhoven, Holland, in 1904. In 1922 he joined the Philips (Radio) Research Laboratories, and in 1927 obtained, by self-study, his B. Sc. degree. To finalize his education, he attended the University of Utrecht, from 1927 to 1930, taking courses in physics and mathematics. Dr. Custers Graduated in 1931, having already returned to Philips as Junior Physicist. He stayed with this company until 1947, when he settled in South Africa and joined the staff of the Diamond Research Laboratory as Senior Physicist, being requested to carry out fundamental research on diamonds. In January, 1953, he was nominated Director of Research of the Institute. In this capacity he visited America several times to lecture on the variation of hardness of the diamond crystal dependent on its orientation. Dr. Custers writes regularly for scientific magazines and journals. His article, *Minor Element in Diamonds and Their Effect on Diamond Colors,* appears in this issue on page 111.

G. Robert Crowningshield, author of the article *Spectroscopic Recognition of Yellow Bombarded Diamonds,* on page 99 of this issue, is Director of the New York Gem Trade Laboratory of the Gemological Institute of America. He joined the staff of the Institute in 1947, shortly after completing his gemological studies. He attended high school in Spring Valley, California, and then San Diego State College, from which he was graduated shortly before entering the Navy in World War II. During the years he has been with the Institute he has had the opportunity of examining many thousands of gemstones and pieces of jewelry. Crowningshield has contributed many articles to past issues of GEMS & GEMOLOGY, for example, *Costuming and the Sale of Colored-Stone Jewelry,* a 2-part comprehensive article in the Summer and Fall, 1953, issues, and *New or Unusual Gem Materials Encountered in the Institute Gem Trade Laboratories,* which appeared in the Summer, 1957