Blue-green Emerald from Nigeria (A consideration of terminology)

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A discussion of green beryl vs. emerald terminology has commenced because of the discovery of blue-green chromium bearing beryls from Nigeria. Previously the locality was described mainly as an aquamarine deposit, but emeralds were also mentioned by Lind[1]. As these blue-green emeralds have now reached the market, I would like to summarise the possible factors that could determine which name should be applied to this beryl.

Emerald is a green variety of beryl in which the colour is due to chromium (and vanadium). This is a historicallly used formula, accepted by CIBJO[2], and supported by ICA (International Color Gemstone Association). Generally the name emerald is applied to any beryl, as long as it is perceived as green (light green, medium strong green emerald etc.), and its green colour is caused by the chromophore element chromium. No master stone exists for the purpose of distinguishing between emerald and light green emerald. Paralleling development in the ruby/pink ruby (formerly pink sapphire) argument, I do not feel that emeralds (or rubies) must possess a certain saturation of green (or red) to earn their valued name. As nature does not discriminate between light and darker green emerald (or rubies), why should light green emeralds be called green beryl. For example, light green Colombian emeralds often owe their green colour to chromium (and very often also a little vanadium. See Sinkankas[3] and Bosshart[4].

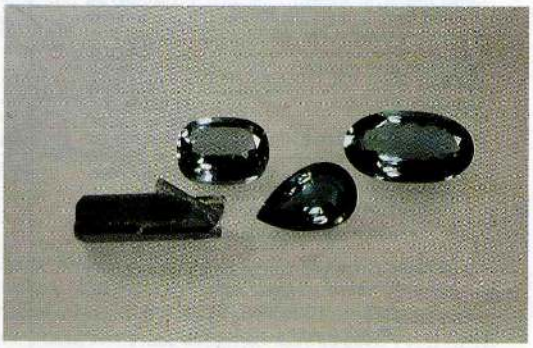

Fig. 1. A rough crystal and three cut stones of blue-green emerald from Nigeria. The crystal is four centimeters long.

As no one has proposed that different names be used to describe darker and lighter aquamarine or blue sapphire, why should other gemstones, such as emerald be described differently? Neither the trade, nor any organistion, has presented a generally accepted instrument or a concept to subdivide the lighter and darker rubies or emeralds. Therefore there is no generally accepted means of discriminating either rubies and "pink sapphire", or emerald and light emeralds, which some call "green beryl". There is also no need to do so, because a term like "ruby" or "emerald" is just a varietal name. The term "emerald" does not express a quality, nor does it determine value. A rich green emerald need not be a valuable gem due to either its name and colour; it could be an unattractive and inexpensive stone due to fractures, inclusions and bad shape.

Green Beryl is a variety of beryl with colour due to iron. It is a mixed colour of yellow (golden beryl), due to bivalent iron. Beryl with an excess of blue is greenish blue, while beryl with an excess of yellow is greenish yellow. Mixtures of trivalent and divalent iron in green beryls, make these beryls look very different from emeralds. This difference is well demonstrated by green beryls from Madagascar and Russia.

Blue-green emeralds were first reported from Zambia about 1974. Schmetzer & Bank (1981) have explained the peculiar colour of those stones as being emeralds with a remarkable iron content, that

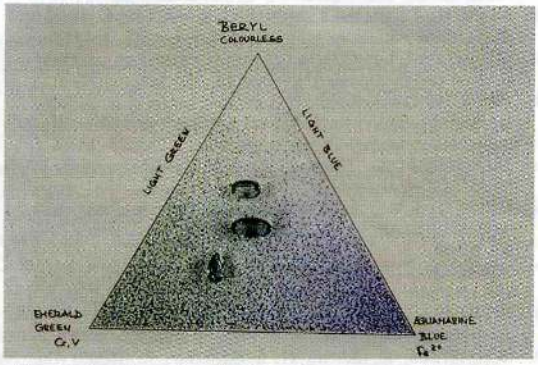

Fig. 2. A colour triangle for colourless beryl, emerald, aquamarine and their mixtures. The faceted stones are placed into the triangle according to their share of the three components of colour.

produced an unusual dichroism for emerald. The gemstone was immediately accepted as emerald, although the stones had a considerable component of aquamarine due to bivalent iron. These Zambian beryls were mixtures of emerald with aquamarine. They possessed both causes of colour and had mixed colours. The balance between green (chromium) and blue (bivalent iron) seems to favour the green side, although a bluish tinge was visible in those stones.

An investigation on the blue-green beryl from Nigeria (Fig. 1) proved it to be from similar composition, although green and blue was more evenly balanced, and the colourless component was stronger. This led to lighter saturations. The colour of Nigerian blue-green beryl can be best understood in a colour triangle where emerald green (Cr,V), aquamarine blue (bivalent iron) and colourless beryl are located at the apexes (Fig. 2). Light green or light blue is located on the edge between the green or blue and the colourless apexes. Mixed colours are situated within the triangle, depending on the relative amounts of constituent colours. Medium light blue-green emeralds from Nigeria may be placed in the centre of the triangle. The presence of iron and little chromium (and vanadium) in the blue-green crystals from Nigeria has been shown by EDS XFA analytical technique (Fig. 3). Thus the chromium necessary to allow the name emerald to be applied is detected. A chromium absorption line is also detectable by absorption spectrophotometry (Fig. 4), or by skilled use of a spectroscope. In addition, the spiky multiphase inclusion of Nigerian blue-green emerald resemble those found in Colombian emeralds. However Nigerian emerald shows more than one kind of crystal inclusions as well as the liquid and gas bubble inclusions.

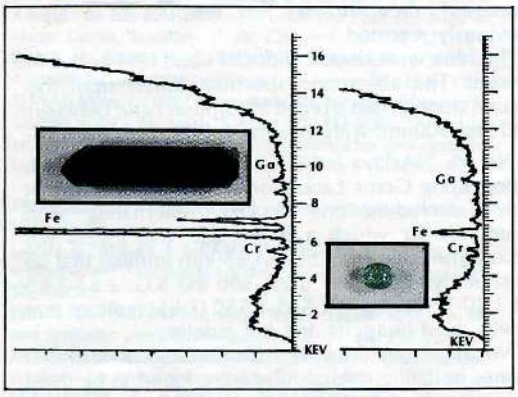

Fig. 3. Energy dispersive spectrum of a Nigerian blue-green emerald (left) and a light green Colombian emerald cabochon. The peaks indicate the relative content of vanadium, chromium and iron.

It is true that there is not as much chromium in Nigerian blue-green emerald than is normally seen in a Zambian emerald, but the chromium is still able to cause the green shade that is not masked by the blue of its aquamarine content.

HOW TO DEAL WITH DISPUTED CASES WHERE SOME GEMMOLOGISTS WOULD RATHER NOT USE THE TERM "EMERALD"

A proposal has been made to establish a chromium content that determines a lower limit for emerald. This is firstly not convenient nor practical for the analytical instrument required, an electron microprobe, is large and expensive. Secondly this proposal does not consider the size and cut of the stone, both of which determine the distance light travels through a stone, and thus the strength of absorption or intensity of colour. Thirdly, a lower limit value for chromium in emeralds does not exclude the possibility, that the chromium green is superimposed by another colour, when the presence of another chromophore element is more dominant.

I think that common sense, the nomenclature rules, scientific considerations, and practical possibilities allow and recommend use of the term blue-green **emerald** for those beryls in which green (due to chromium) is a visible part of the blue-green mixed colour. With the colour discription "blue-green" we may put a signal that the emerald under consideration is in one respect different from what one might expect from a "normal" emerald, coloured by chromium only.

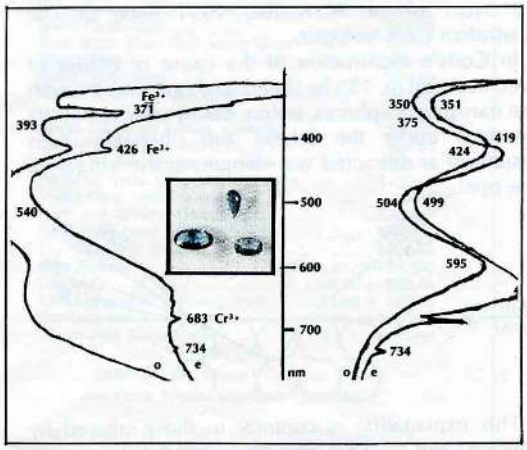

Fig. 4. Absorption spectra recorded with a spectrophotometer of a rich green Colombian emerald (right) and a light blue-green emerald from Nigeria. The characteristic chromium line at 683 nm is visible in both spectra.

But this "normal" emerald is a theoretical gemstone that may be so rare in nature, that it has no relevance to the emeralds traded throughout the world. The colours of commercial emeralds consist of a mixture of chromophore elements (Cr, V, Fe^{2+}, Fe^{3+}). This ionic cocktail was offered to the growing emeralds of the world by their different parent rocks. The result is the big variety of shades and tones which apparently overstrain the simple concept of commercial categorisation.

ACKNOWLEDGEMENT

I gratefully acknowledge the contribution of Richard Hughes, AIGS, Bangkok. We discussed the matter of quality versus origin and variety during the ICA Conference in Hawaii 1991. My thanks also go to Mr. K.E. Wild from Kirschweiler, Germany, who kindly supplied the study material of Nigerian beryls (both emerald and aquamarine).

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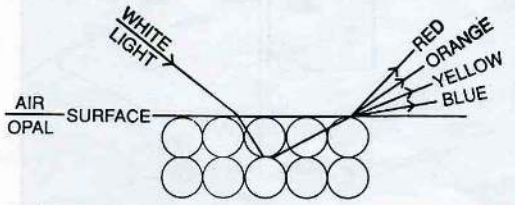
Letter to the Editor

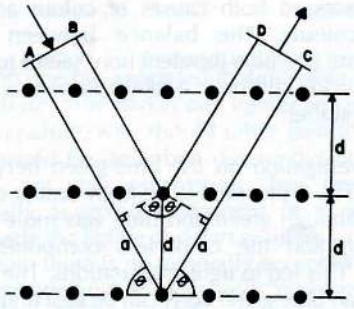
Dear Sir,

Corinne Sutherland has drawn my attention to a minor interpretational error that appeared in Andrew Cody's book *Australian Precious Opal*, reviewed on pp 540-1 of the November 1991 issue of *The Australian Gemmologist*.

In Cody's explanation of the cause of colour of precious opal (p. 15), he stated 'Light passses through the transparent spheres, before being reflected at the interface under the sphere and ultimately then dispersed as diffracted wavelengths at the surface of the opal.



This explanation is contrary to those offered by Sanders[1] and Nassau[2] who suggest that diffraction in precious opal is due to slight differences in refractive index between three dimensionally stacked even sized spheres of amorphous silica and the aqueous silica that cements the spheres together. Indeed Nassau's figure 12-28 (p 279) clearly indicates that diffraction occurs at regularly stacked sphere-interfaces when 'the angle of incidence for diffraction from a layer equals the angle of reflection and when the path difference between this reflection from adjacent layers is a whole number of wavelength'.



Perhaps an errata should be added to this otherwise excellent book.

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G.Brown

ICA LABORATORY ALERTS

No 48. From the Gem Testing Laboratory, Jaipur, India. Two emeralds, fashioned into cabochons and from a parcel purchased as Swat rough were found to be synthetics. Both exhibited a cross-hatch appearance along the optic axis indicating strain; the larger stone was traversed by large cracks which gave off a strong reflection in oblique light, and immersed, showed dendritic markings along each crack.

No 26 (Update). The German Foundation for Gemstone Research reports more flux-grown synthetic red and blue spinels said to have come from Sri Lanka. The gemmological constants are typical for natural spinels, but were identified microscopically as when immersed, they showed flux residues of a type previously reported.

The blue were doped with Co^{2+} and iron was also present. The absorption spectrum differs from the natural stone; it had a broad absorption band between 700 and 500nm, with maxima at 549, 584 and 627.

No 49. "Malaya Jade" — Jadeite imitation. From Hong Kong Gems Laboratory; a report of "Malaya Jade", including one necklace alternating with diamonds for which a high price was asked. An absorption band from 660 to 680nm implied that an organic dye had been used, and the S.G. 2.63-2.65 (cf 3.30-3.36) and RI 1.545-1.550 (1.66) indicate that it was dyed quartzite and not jadeite.

No 50. From the Swiss Gemmological Institute. Stones imitating natural ruby were found to be dyed natural corundum. Probably stained during quench cracking, the stones had inclusions resemebling some stones from East Africa. The colour is restricted to the cracks, the stones fluoresce yellow under long wave UV, and show no trace of a chromium spectrum.

The possibility of distinguishing natural from synthetic alexandrite by infrared spectroscopy has been described by Stockton & Kane[10]. Typical features have been determined in the 200-4200cm^{-1} (2380-5000 nm) range.

The alexandrite investigated possesses distinct vibrational bands in the 2700-3400cm^{-1} (2940-3700 nm) spectral region as well as in the range of 2400cm^{-1} (4170 nm) (Fig. 6a), which are typical for natural alexandrites and are caused by vibrations of H_2O and OH molecules, incorporated during the growth as well as by fluid-inclusions.

A broad vibrational band has three maxima at 3130, 2930 and 2840cm^{-1} (3185,3410 and 3520 nm) and at 2400cm^{-1} (4170 nm) a sharp peak is visible. In comparison with the spectrum of a flux-grown synthetic alexandrite produced by Creative Crystals, USA (Fig. 6b), the different features are distinct; the synthetic stone shows only weak vibrational bands with maxima at 2960 and 2670cm^{-1} (3380 and 3745 nm).

Consequently, the spectroscopical investigations of the alexandrite in question showed diagnostic features for a natural stone as far as IR-absorption is concerned.

RAMAN SPECTROSCOPY

For the definite identification of the tabular black inclusion Raman spectroscopy has been applied, which determined the inclusion as hematite and consequently as a typical and diagnostic inclusion feature of a natural alexandrite.

ACKNOWLEDGEMENT

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