Blue Halos in Sapphires

Another ISG - International School of Gemology

MYTH BUSTER

ISG's Facebook page incorrectly states:

> When sapphires are diffusion treated with beryllium, residual iron-titanium in the sapphire reforms around inclusions inside the stone.

Additionally, YourGemologist.com (an ISG webpage) article *BE Treated Sapphire* incorrectly mentions:

> …blue halos which are the result of residual iron and titanium reforming their bond around pre-existing crystals.

These statements are wrong on so many levels, but first, a brief review of gemological history is in order.

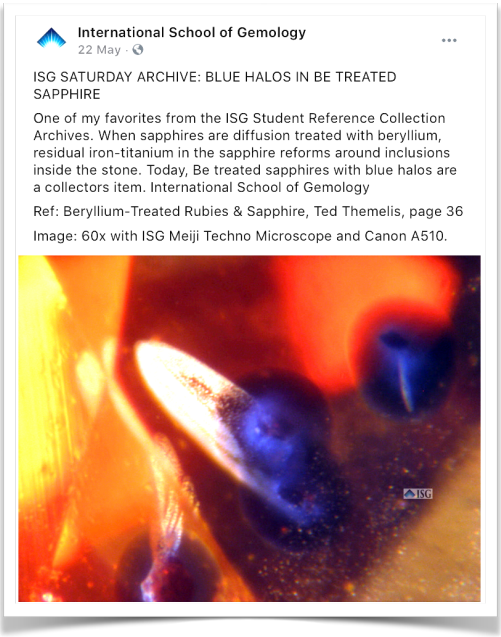


Figure 1. Incorrectly explained blue halos by ISG of Texas

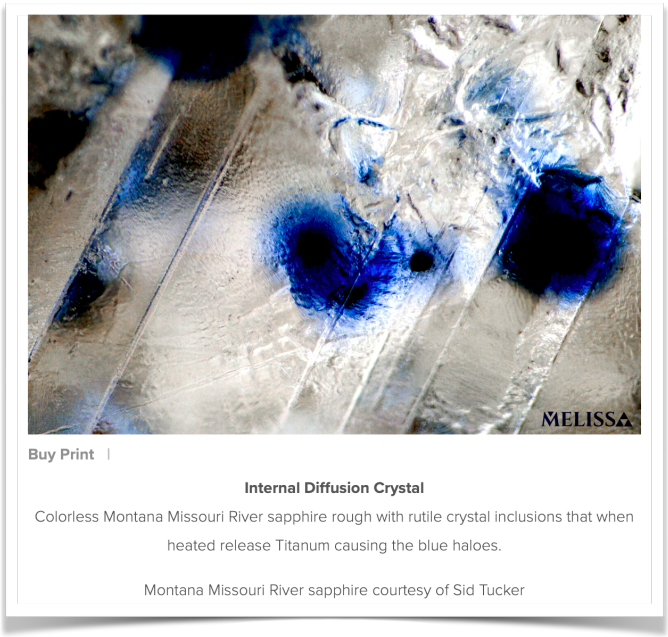


Figure 2. Correctly explained blue halos by gemologist Melissa Allen of Texas

The cause of blue discs/halos in heated sapphires from Sri Lanka and Montana were first documented by John I. Koivula in his 1987 *Journal of Gemmology* article *Internal diffusion* (Koivula, 1987). Diffusion in corundum is a process by which atoms and ions can migrate through the solid crystal structure if the temperature is sufficiently high. Koivula explains that blue-colored halos can be generated around inclusions during high temperature heat treatment if the temperature is high enough to volatilize the inclusion without melting the host.

Back to Basics

100% pure corundum is colorless with a chemical formula of Al_2O_3. The presence of trace amounts of certain metals generate the various colors; chromium (Cr) causes red, iron (Fe) and titanium (Ti) are responsible for blue, yellow and green, and a mixture of all three produce purple and violet. Trapped hole color centers generate yellow and orange colors. Vanadium produces color-change stones. The chemical formula of blue sapphire can be represented as $Al_2(Fe,Ti)O_3$, or more precisely $Al_2(Fe^{2+},Ti^{4+})O_3$ (Dubinsky et al., 2020).

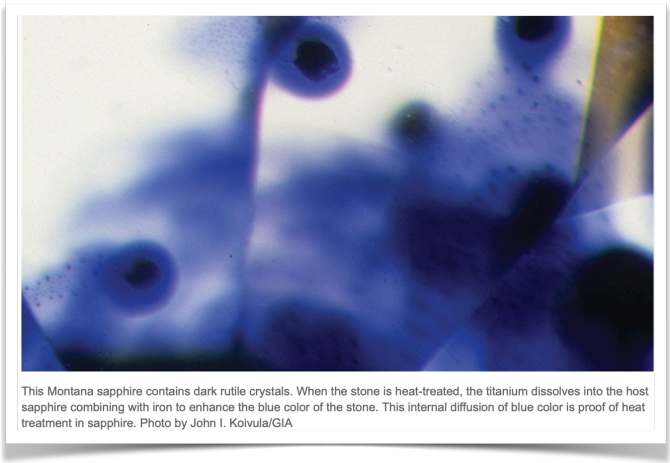


Figure 3. Blue halos around rutile inclusions in heated Montana sapphire.

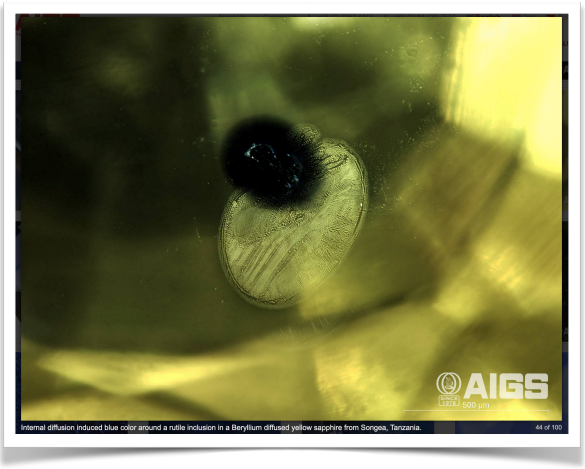


Figure 4. Blue halo around rutile in heated sapphire from Tanzania.

Rutile ($TI0_2$), ilmenite ($FeTiO_3$), and titaniferous hematite ($Fe^{2+}(Fe^{3+},Ti)_2O_4$) are recognized as common mineral inclusions in sapphires from various sources. If titanium is present as the chemical components of an inclusion, then, as Koivula mentioned, a blue-colored halo would be generated around that inclusion during high temperature heat treatment through a process known as “internal diffusion.” At 1800°C and above, but keeping well below the melting point of 2050°C, the inclusions are essentially cannibalized as titanium diffuses out from the inclusions and into solid solution in the surrounding corundum. This process, where atoms migrate from areas of high concentration to areas of low concentration is termed “diffusion,” and in this particular situation, results in a blue halo surrounding the inclusion.

In fact, the diffusion of Fe in corundum is quite slow, but Ti diffuses far more quickly, so the blue halos result from diffused Ti reacting with Fe already in the surrounding corundum. For the science geeks out there, this reaction of Ti with Fe in corundum is termed “trap diffusion.” The Fe-Ti charge transfer mechanism in corundum is extremely efficient, required just a few parts per million to generate significant color. This is roughly 25 times more efficient in creating color than the Cr in ruby.

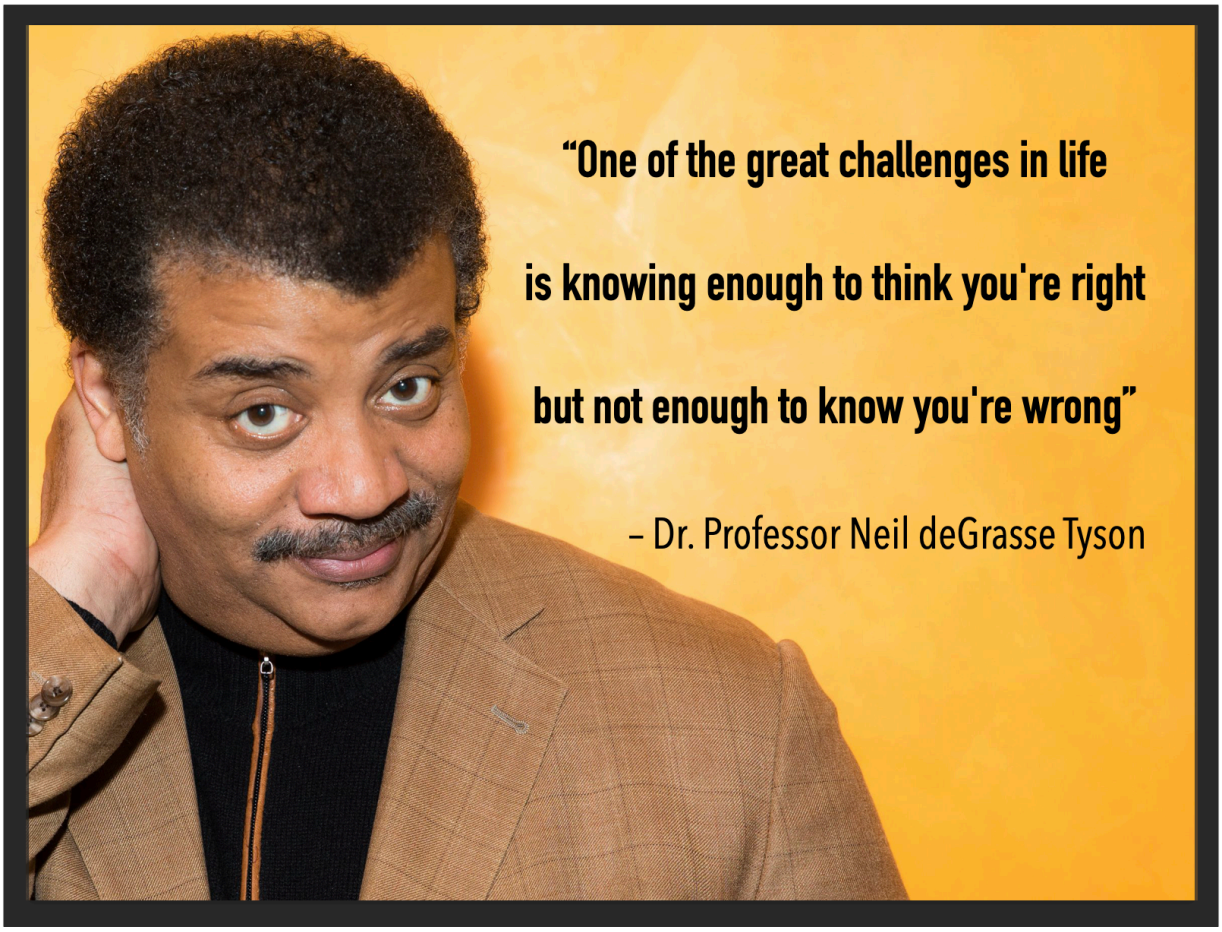
Diffusion Confusion

In 2001, large numbers of “padparadscha” sapphires became suddenly and inexplicably available in the Thai gem market. By 2002, it became apparent that corundum was being treated by a new technique involving high temperature bulk diffusion of the light element beryllium (Be) which generated artificially induced reds, oranges and yellows. January 8, 2002, the first trade alert was issued by the American Gem Trade Association (AGTA) prompting intensive research in gemological laboratories worldwide. The vast majority of this new material was from Tanzania where rutile, ilmenite and titaniferous hematite are common inclusions.

As the new high temperature beryllium diffused sapphires made their way into the hands of gemologists around the world, many reported the blue halos as an often encountered feature. **It was widely understood that the formation of the blue halos was strictly due to the high temperature, and had nothing to do with the red, orange and yellow colors induced by beryllium. In other words, the same blue halos could be created with heat alone, completely in the absence of beryllium.**

Ignorance - No Excuse

So, how is it a gemology school around for two decades could be so wrong about the cause of the blue haloes? Let’s take a look at what the ISG professor himself has to say…



> But I hate trying to read off those long and very boring chemical equations. Sorry, but I really don't care about them.
>
> – Robert James, *Making Gemstones out of Household Kitchen Products!*
> a publication of the International School Gemology, August 3, 2021

So there you have it; willful ignorance! A gemology professor who doesn't care about chemical equations because he finds them "very boring". So, when ISG erroneously states "When sapphires are diffusion treated with beryllium, residual iron-titanium in the sapphire reforms around inclusions inside the stone" and "These include blue halos which are the result of residual iron and titanium reforming their bond around pre-existing crystals" we understand they are wrong because they just don't care about such boring subjects as chemistry, a critical and foundational component of the science of gemology.

> One of the great challenges in life is knowing enough to think you're right but not enough to know you're wrong.
>
> – Neil deGrasse Tyson
> American astrophysicist, scientist, author and science communicator

Award Presentation

The *Dunning-Kruger effect* occurs when a person's lack of knowledge and skills in a certain area cause them to overestimate their own competence. In this respect, I award the coveted "Dunning-Kruger Award for Perceived Excellence in Science" to the "Professor" of the ISG, the notorious International School of Gemology of Helotes, Texas!

The Award Winning Professor!

It is no wonder my many good friends in The Gobsmacked Gang created the informative, fact-filled website BadGemology.com to expose the ongoing gemological blunders of the ISG.

It always has been, and always will be about one thing, and one thing only; The Gemology!

For more of the Bad Gemology the International School of Gemology is notorious for see:

ISG ALL FLUXED UP **2020 ISG BLOOPERS** **ISG BLOOPERS & WHOPPERS**

MONTANA SAPPHIRE MYTH BUSTER

Photo Credits

Photo 1. ISG SATURDAY ARCHIVE - BLUE HALOS IN BE TREATED SAPPHIRE (Accessed 08-08-2021)

Photo 2. Gemologist Melissa Allen - Colorless Montana Missouri River sapphire rough with rutile crystal inclusions that when heated release Titanium causing the blue haloes. Montana Missouri River sapphire courtesy of Sid Tucker (Accessed 08-08-2021)

Photo 3. John Emmett/GIA - This Montana sapphire contains dark rutile crystals. When the stone is heat-treated, the titanium dissolves into the host sapphire combining with iron to enhance the blue color of the stone. This internal diffusion of blue color is proof of heat treatment in sapphire. Photo by John I. Koivula/GIA (Accessed 08-08-2021)

Photo 4. AIGS - Internal diffusion induced blue color around a rutile inclusion in a beryllium diffused yellow sapphire from Songea, Tanzania. (Accessed 08-08-2021)

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About the Author

With humble roots from a non-gem trade family, as a lapidary hobbyist, Jeffery cut and polished his first gemstone at the age of fourteen launching him on a lifelong career which has taken him to more than 70 countries, and every continent except Antarctica. With 5 decades of broad-based experience in natural gemstones, diamonds and fine jewelry, in 2020 Jeffery founded Eighth Dimension Gems (formerly Primagem) in Bangkok, Thailand, where he has lived for over 30 years.

Jeffery's formal gemmological training was accomplished at the prestigious Swiss Gemmological Institute in Basel, Switzerland where he passed requisite exams for his SSEF Basic Gemmology (BGC) and SSEF Basic Diamonds (BDC) Diplomas. Additionally, he completed SSEF's Advanced Pearls (ATC), Advanced Colored Stones (ATC) and Scientific Gemmology (SGC) courses, and is privileged to be an active Accredited Senior Gemologist voting member of the AGA – Accredited Gemologists Association.

Featured in many gem and jewelry periodicals, Jeffery has also appeared in interviews on the ABC, BBC, CCTV, CNA, CNN, NBC and GEO. He has been quoted in Time, USA Today, National Geographic, Discover, GIA's Gems & Gemology, Gem-A's Journal of Gemmology, ICA's InColor, Rivista Italiana di Gemmologia/Italian Gemological Review and many other publications around the world. A guest speaker at seven GIA Gem Gatherings as well as many gemological conferences & universities, Jeffery is also an Honorary Professor for the AIGS – Asian Institute of Gemological Sciences in Bangkok, Thailand, and pro bono Vice President, Emeritus of the IGS - International Gem Society.

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The SSEF Swiss Gemmological Institute hereby confirms that

JEFFERY BERGMAN
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has participated at the SSEF Basic Training Courses in gemmology at the SSEF Swiss Gemmological Institute in Basel and successfully passed the theoretical and practical SSEF Basic Gemmologist examination on 15 July 2014.

Basel, 23 July 2014 dh

Sebastian Hänsel, MSc
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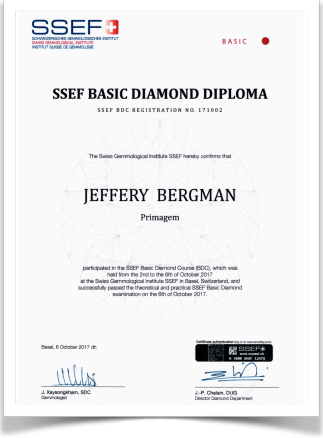
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The Swiss Gemmological Institute SSEF hereby confirms that

JEFFERY BERGMAN
Primagem

participated in the SSEF Basic Diamond Course (BDC), which was held from the 2nd to the 6th of October 2017 at the Swiss Gemmological Institute SSEF in Basel, Switzerland, and successfully passed the theoretical and practical SSEF Basic Diamond examination on the 6th of October 2017.

Basel, 6 October 2017 dh

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