Beryllium Treated Blue Sapphires

Continuing market observations and update including the emergence of larger size stones

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Figure 1: A blue sapphire recently examined in the laboratory weighing 22.52ct was determined to contain 7.50 - 9.50 ppma of beryllium by using LA-ICP-MS. Photo: Suchada Kittayachaiwattana © GIA

Abstract

This paper, which constitutes a small portion of an on-going project, is an update on the presence in the market of beryllium treated blue sapphires, the types of material and their identifying characteristics. Five commercial quality (in the 1ct range) beryllium treated blue sapphires that are representative of a large parcel recently purchased on the Bangkok market are described with details of their chemistry, inclusion scenes and optical data. Further, two large 22ct and 53ct beryllium treated blue sapphires that are reportedly treated by a different technique are also described. The data reveals several types of start material are used for the beryllium treatment of blue sapphires but that in each case there are important clues that lead the gemologist toward the nature of the treatment with the ultimate test being analysis using LA-ICP-MS.

Acknowledgements

The authors acknowledge with thanks the continued assistance being given to them as this project progresses by John Emmett, Terry Coldham and Thawatchai Somjaineuk.

Introduction

In 2003 (Emmett, et al., 2003) Emmett discussed ("From our analysis of the impact of beryllium diffusion on very dark blue sapphires where [Ti4+] >> [Mg2+], we find that beryllium diffusion should produce the condition [Ti4+] > [Mg2+ + Be2+], substantially reducing the blue color saturation") and showed how over-dark blue sapphires could be lightened to a more commercial blue. It is also worthy of note that Emmett (Emmett, 2007) in a memo to the "corundum group" (a small group of gemologically minded individuals with a strong interest in the chemistry and physics of corundum) and following further research, states that the beryllium ppm range required for visible color alteration in blue sapphire is as little as between 0.5 and 1.5 ppma (1ppma = 0.45ppmw).

In July 2003 and again in July 2004 Gemmological Association of All Japan reported to members of the Laboratory Manual Harmonization Committee that they seemed to be detecting concentrations of Be in some heated blue sapphires (Figure 15). In one instance in 2004 they reported the amount to be 10 to 35ppmw. However, it was not clear at the time if these were intentionally treated along the lines of the Emmett explanation (above) or by some other process, or that they were some of the sapphires that had not turned yellow (but nevertheless were diffused with Be) during the beryllium treatment processes used to create the yellow and padparadscha colors that were the focus of treaters during that period (Figure 2). The GAAJ were also at this time using their newly acquired LA-ICP-MS which began an era of easier detection of Be and other light elements by gemological laboratories.

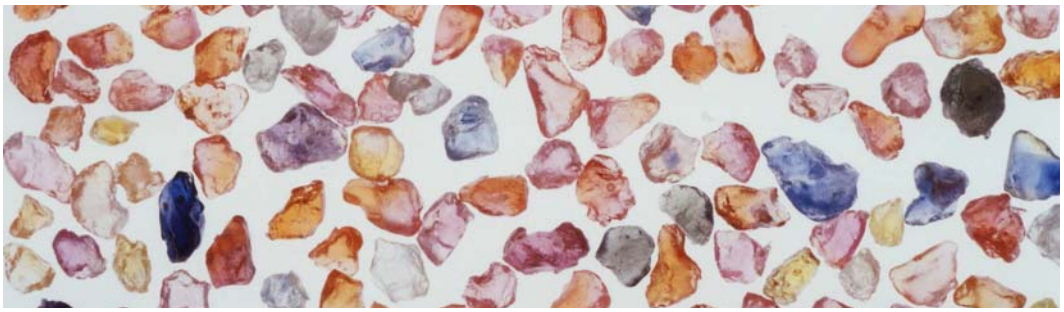

Figure 2: An assortment of corundum following heating with beryllium, note that while many now appear yellow of orange, many remain blue. *Photo: John Emmett from (Emmett, et al., 2003).*

In 2005 while routinely examining stones for Be content Peretti (Peretti, 2005a, Peretti, 2005b) discovered that this or a similar treatment technique had begun to be used to commercially enhance the appearance of blue sapphires. Over the ensuing months several authors examined these Be treated blue sapphires and reported their observations (DuToit, 2006, Pardieu, 2006, Pardieu, 2008).

While the consensus concerning these stones is that analytical data acquired by LA-ICP-MS is required to identify the presence of beryllium in an artificially diffused form (beryllium may also be present naturally in blue sapphires (Pardieu, 2007, Shen, 2007, Pardieu, 2008, Shen, 2009), when present, certain 'characteristic' inclusions scenes may indicate that this treatment had been used (Figure 3).

Five Beryllium treated blue sapphires representing a large parcel

Being located in Bangkok the authors are often asked about treated rubies and sapphires and if many find their way to the laboratory. In the last 12 months several people have asked if many Beryllium treated blue sapphires are submitted for examination to which we answer; no, even though every heated sapphire is checked for Be content very few Be treated stones are discovered within the samples submitted. However, we do expand on this by cautioning that the type of stones that are submitted to laboratories may not be representative of the available material in the market. Indeed after being asked this question a few times, we have gone out into the market and found it relatively easy to obtain large parcels of Be treated blue sapphires (being sold under various name tags) e.g., Figure 4.

Recently Terry Coldham of Sapphex (Australia) knowingly purchased a large parcel of Be treated blue sapphires in Bangkok (example image Figure 4). Upon the stones reaching him in Australia he looked through the lot on his microscope and suspected that they were a little different from the material that had been previously described in the texts. He selected five stones (Table 1) that were representative (Figure 5) and sent them to GIA Laboratory Bangkok for further examination. The stones were all oval faceted and weighed between 0.874 and 1.209ct. The colors varied from light (stone 1) to dark (stone 3) blue in color.

Table 1: Five beryllium treated blue sapphires purchased by Terry Coldham on the Bangkok market in 2009

Sample	Ct weight	Notes
sapphire 1	0.891	Was oval faceted; now polished to an optically oriented cube
sapphire 2	0.874	
sapphire 3	1.101	
sapphire 4	1.209	Was oval faceted; now polished to a thin section see Figure 5
sapphire 5	0.883	

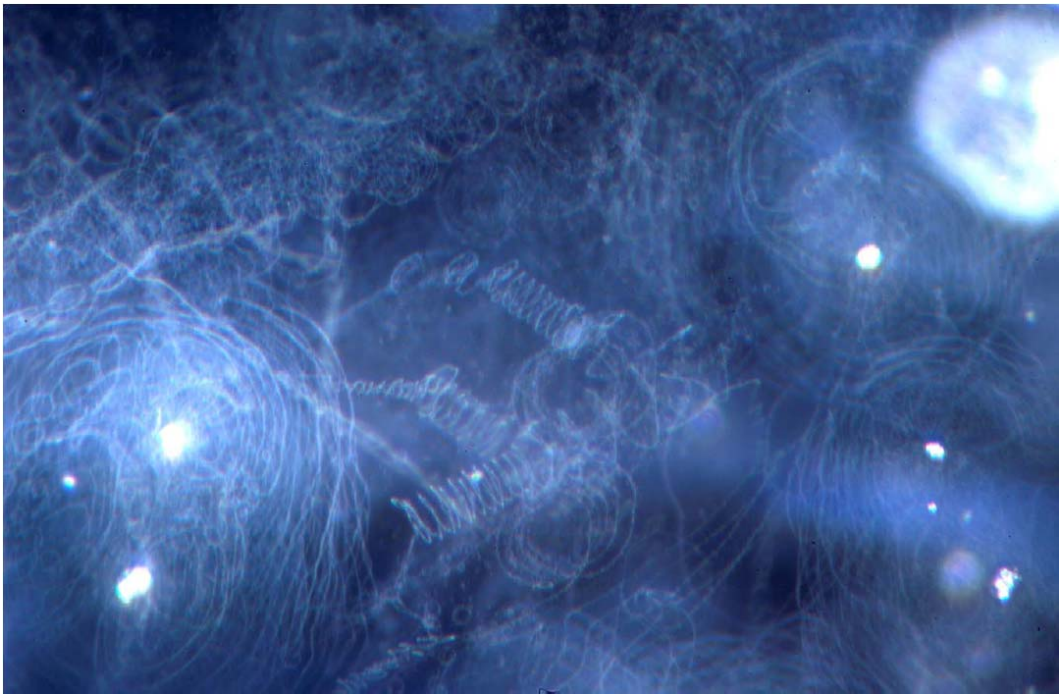

Figure 3: The web and spring-like inclusion scene often recorded in Beryllium treated blue sapphires. *Photo Shane McClure @ GIA*

Figure 4: An image example of Be treated blue sapphires currently on the Bangkok market (*photo Terry Coldham*)

Figure 5: Five Be treated blue sapphires selected as a representative sample from a larger lot purchased in Bangkok in March 2009. They are from left to right 1 (0.891ct), 2 (0.874ct), 3 (1.101ct), 4 (1.209ct) and 5 (0.883ct).

Beryllium and other trace element content

Upon receipt of the five stones (Figure 5) and as these had been sold as Be treated blue sapphires, they were firstly analyzed using LA-ICP-MS. Three spots were chosen at random on the girdle of each stone for analysis and the results are set out in Table 1. All of the stones were found to contain beryllium, with some spots recording quite high levels. The Be levels recorded ranged from 11.77 to 45.15ppma. Other element levels were also recorded with Nb and Ta having no concentrations (in stones that contain beryllium naturally the Be tends to correlate with the presence of these two elements (and potentially others) which is not the case for artificially treated stones (Shen, 2007, Shen, 2009). In comparison with the Ti composition relatively high Mg concentrations were recorded for these samples which does not fit well with the [Ti4+] > [Mg2+ + Be2+] scenario for lightening dark blue sapphires as presented by Emmett (Emmett*, et al.*, 2003) as one of the reasons for treating blue sapphires by this method. Indeed the description given of the process amongst traders in Bangkok is that the stones are darkened by the Be treatment and not lightened; something that is either reported conjecture or a process we do not presently understand.

Table 2: The beryllium levels found to be present at three spots for each of the Be treated blue sapphires depicted in Figure 3, plus the levels for Ti. V, Cr, Fe and Ga in ppma.

Sample	Be	Mg	Ti	Cr	Fe	Ga
sapphire 1_sp1	13.43	35.18	30.65	0.00	193.00	16.46
sapphire 1_sp2	10.83	35.17	29.51	1.47	187.67	16.26
sapphire 1_sp3	11.77	20.90	16.67	4.81	174.42	15.56
sapphire 2_sp1	15.87	44.77	37.21	5.31	573.60	17.57
sapphire 2_sp2	16.84	47.23	40.05	4.86	487.44	17.72
sapphire 2_sp3	13.69	41.72	41.59	5.74	637.87	18.63
sapphire 3_sp1	27.36	22.87	22.65	9.12	722.57	16.30
sapphire 3_sp2	45.15	25.40	24.54	10.59	725.13	16.29
sapphire 3_sp3	15.25	28.54	28.35	9.89	733.16	15.74
sapphire 4_sp1	14.27	25.95	26.02	5.69	250.91	17.83
sapphire 4_sp2	14.98	29.98	26.03	5.96	281.73	18.65
sapphire 4_sp3	15.95	28.48	25.63	5.87	273.44	19.17
sapphire 5_sp1	29.45	22.60	27.45	1.10	229.95	12.88
sapphire 5_sp2	18.79	49.16	51.15	2.57	263.98	14.00
sapphire 5_sp3	18.80	62.38	69.46	2.83	277.38	14.18

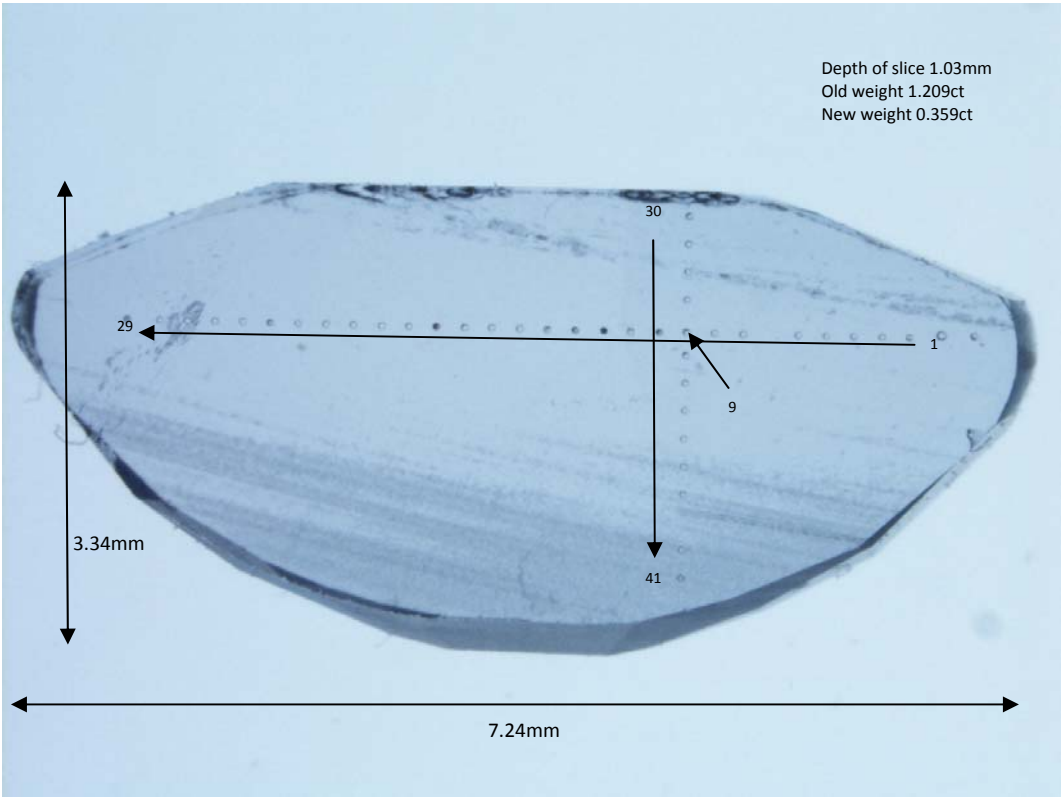

Figure 6: Be treated sapphire number 4 was polished down to a thin slice and sampled at 41 points by LA-ICP-MS to determine the depth or the be penetration along with other element distribution. Note that the ablation spot to the far right was not included in the analysis.

To test the validity of the chemical data obtained at the surface of the faceted stones, and realize the penetration depth of the Be used in the process, stone number 4, originally an oval faceted stone weighing 1.209ct, was ground down and polished to a thin slice without shortening its greatest dimension (Figure 6). The slice was then cleaned in aqua regia [1] in preparation for chemical analysis by LA-ICP-MS. The slice was then analyzed at 41 points from the edges (girdle, culet and table) to the deepest points within the original faced stone (29 points parallel to the original girdle and 12 points from the original table to culet).

The results of the analyses for the elements Be, Mg, Ti, Cr, Fe and Ga are presented in Table 3. These results show a relatively even distribution of Mg, Ti, Cr, Fe and Ga (Figure 7) for each of the points analyzed but for Be there tends to be larger concentration towards the edges when compared with the center of the stone examined (Figure 8 and Figure 9). This tendency of a lower Be concentration towards the center is to be expected for a situation where the element has been diffused into a faceted or preformed stone.

[1] Aqua regia is a 1:3 mixture of nitric and hydrochloric acids used to clean any polishing residues that might interfere with a chemical analysis.

Table 3: The concentrations (in ppma) for Be, Mg, Ti, Fe and Ga taken girdle to girdle and table to culet recorded for sapphire #4 after being polished down to a thin slice (Figure 6) from the original oval faceted form (Figure 5).

Spot	Be	Mg	Ti	Cr	Fe	Ga
1	12.71	27.04	23.80	7.29	471.71	18.47
2	12.32	28.35	21.49	9.85	465.14	18.80
3	10.96	29.13	23.81	11.08	487.04	19.97
4	9.86	30.50	22.59	11.81	465.50	19.12
5	10.12	29.59	22.90	12.35	470.98	18.85
6	11.04	29.32	26.11	11.54	479.38	18.99
7	9.26	29.67	23.69	9.59	473.53	17.66
8	9.35	32.91	25.34	10.71	468.42	18.14
9	9.36	27.98	25.60	11.47	467.69	18.85
10	6.74	26.51	24.01	11.60	464.77	19.19
11	8.44	31.86	22.90	10.97	457.47	18.66
12	8.80	33.68	24.23	12.10	481.20	18.85
13	8.55	27.89	25.68	9.36	469.15	19.07
14	6.94	30.88	23.93	11.71	474.63	18.39
15	7.46	31.63	24.98	11.53	476.09	18.26
16	6.85	31.68	22.24	11.56	468.42	18.38
17	6.63	30.31	24.18	10.62	483.39	18.64
18	7.19	31.21	23.59	11.64	470.61	18.85
19	7.48	31.56	22.82	11.05	461.85	18.51
20	9.08	33.86	23.31	11.60	457.11	18.69
21	8.22	33.39	24.07	9.28	449.80	18.39
22	7.65	32.09	22.76	11.66	471.71	18.68
23	8.48	32.51	25.08	9.89	464.41	18.52
24	9.03	28.30	23.20	10.44	466.60	18.61
25	11.17	30.21	24.83	11.25	475.73	17.75
26	12.47	30.15	21.31	11.26	458.57	19.29
27	11.67	29.07	23.62	10.49	477.19	18.01
28	11.37	28.12	22.09	10.54	476.82	18.33
29	12.74	18.97	21.50	11.41	462.58	18.25
30	10.43	25.74	23.94	11.88	466.96	17.53
31	9.54	28.70	26.01	9.53	489.60	19.13
32	8.15	28.17	24.69	10.80	477.92	18.50
33	9.36	30.79	25.02	13.02	488.14	18.40
34	10.19	30.92	23.10	9.89	467.69	17.65
35	9.28	31.99	24.26	11.64	470.61	17.10
36	10.93	28.91	27.39	11.91	458.20	18.01
37	7.08	31.16	25.04	11.18	463.68	18.47
38	9.42	30.11	25.48	11.34	478.28	18.33
39	11.74	29.69	23.93	10.27	469.88	18.06
40	12.17	28.11	22.99	11.64	459.30	18.33
41	14.36	29.95	22.82	11.80	464.77	18.02

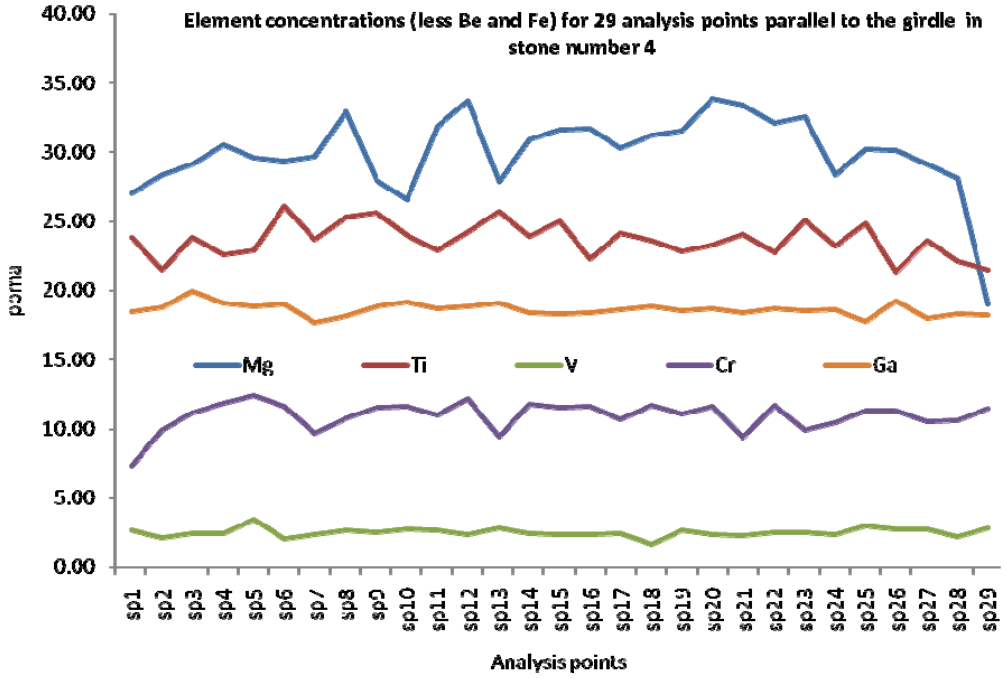

Figure 7: The 29 LA-ICP-MS analysis points parallel with the girdle (Figure 6) for the polished down thin slice of sapphire #4 showing relatively even concentrations of Mg, Ti, V, Cr and Ga across the analysis line.

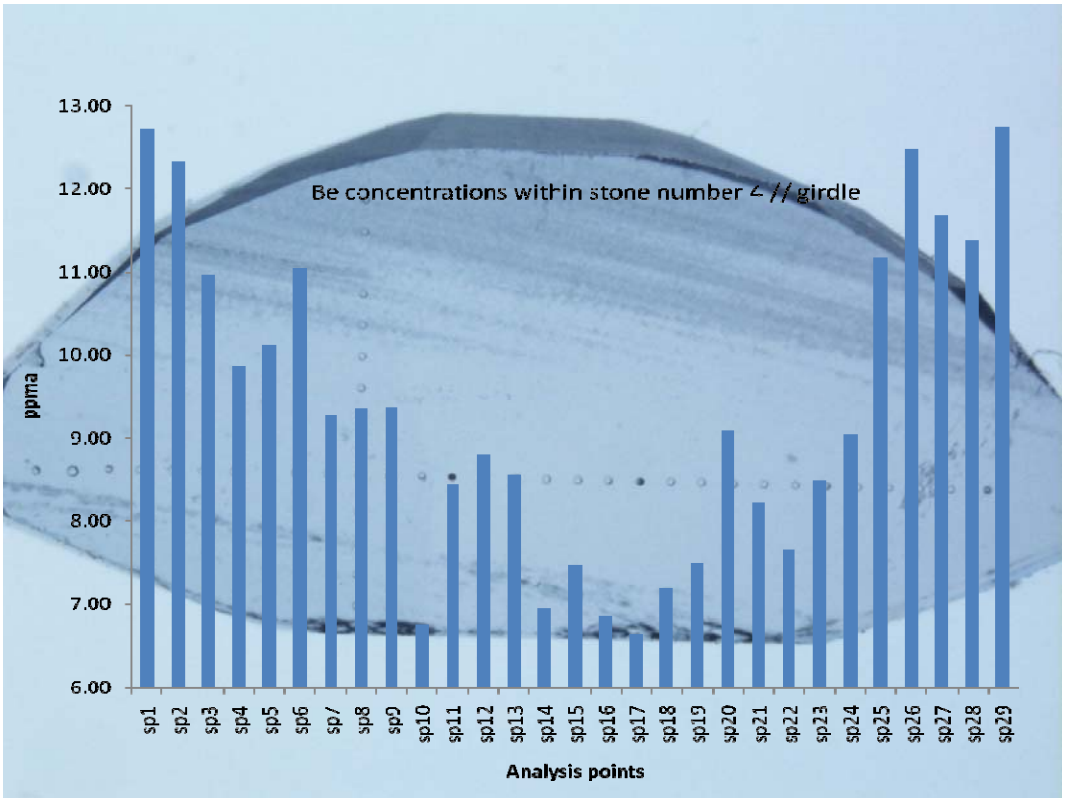

Figure 8: The 29 analysis points taken parallel to the girdle on the polished down thin slice of sapphire #4 show that there is a higher concentration of Be towards the edges (the surface of the original faceted stone) (12-13ppma) compared with the concentrations towards the center (6-8ppma).

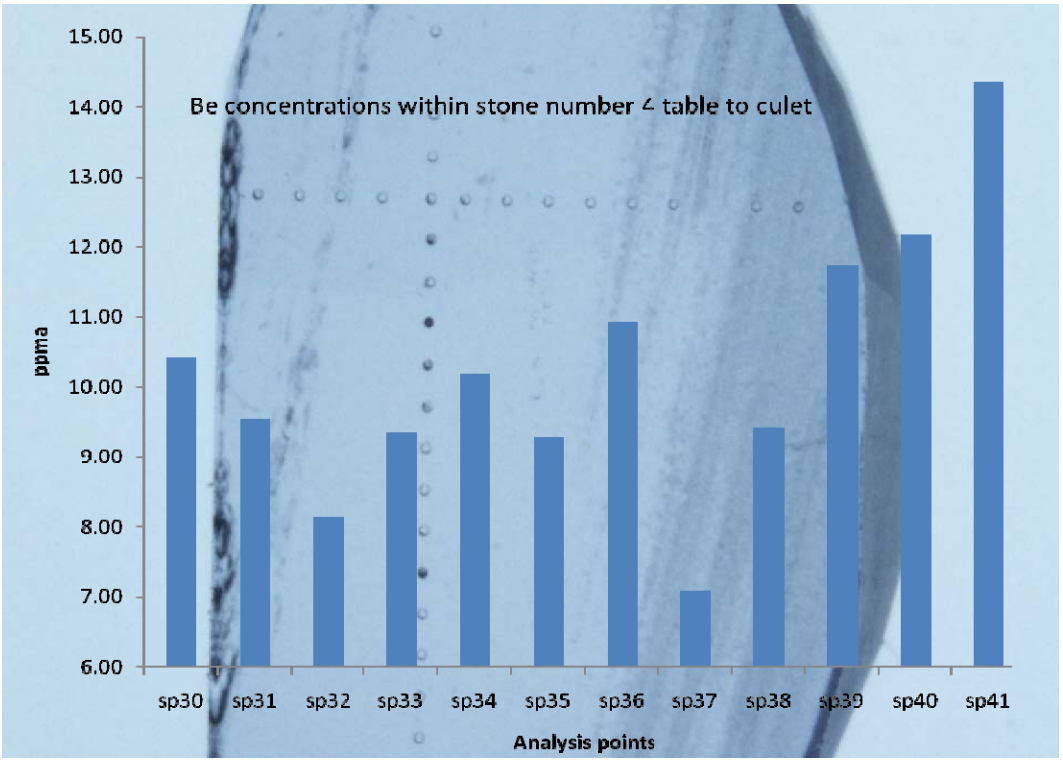

Figure 9: The 12 analysis points taken table to culet on the polished down thin slice of sapphire #4 do not show a similar drop in the concentrations of Be towards the center of the stone.

Inclusion scenes

Of the five submitted, one stone (number 4 Figure 5) was found to be relatively free of inclusions, while the remainder revealed numerous inclusion scenes but all reminiscent of those normal following high temperature heating The inclusion scenes are depicted in Figure 10, Figure 11, Figure 12, and Figure 13.

Stone number 1 (Figure 5) was a little unusual as it contained numerous (previous to heating) crystals that had melted resulting in their replacement with what is probably glass with a shrinkage bubble (Figure 10). Stone number 2, (Figure 5) revealed the total destruction of individual (previously) crystals (from high temperature heating) that are seen now to be surrounded by fine clouds of pin-point inclusions (observed with reflected light from an optical fiber) (Figure 11). In stone number 3 (Figure 5) the treatment process left traces of artificially healed tubes, circular and indistinct coiled spring-like formations (previously reported as being characteristic of Be treated blue sapphires) and heat destroyed (previously) crystals surrounded by fine clouds of pin-point inclusions (Figure 12). In stone #5 (Figure 5) coiled spring-like and web-like formations that have previously been reported as characteristic of Be treated blue sapphires are present as are heat destroyed (previously) crystals surrounded by fine clouds of pin-point inclusions (Figure 13).

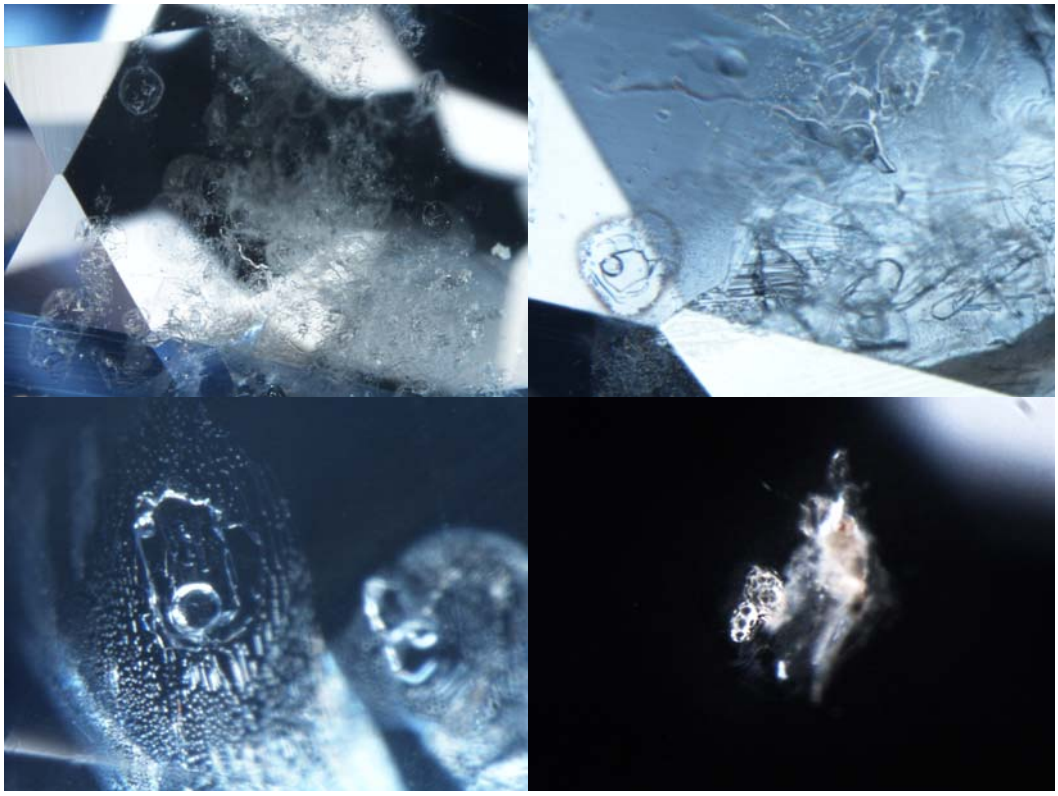

Figure 10: The inclusion scene within an oval 0.891ct (stone #1 Figure 5) Be treated blue sapphire revealing indications of the high temperature heating environment it had experienced during the treatment process. Top left; localized created and/or altered healed fractures surrounding a myriad of (previously) crystal inclusions. Top right and bottom left; melted (previously) crystals with shrinkage bubbles. Bottom right; a group of small (previously) crystals destroyed during the treatment process.

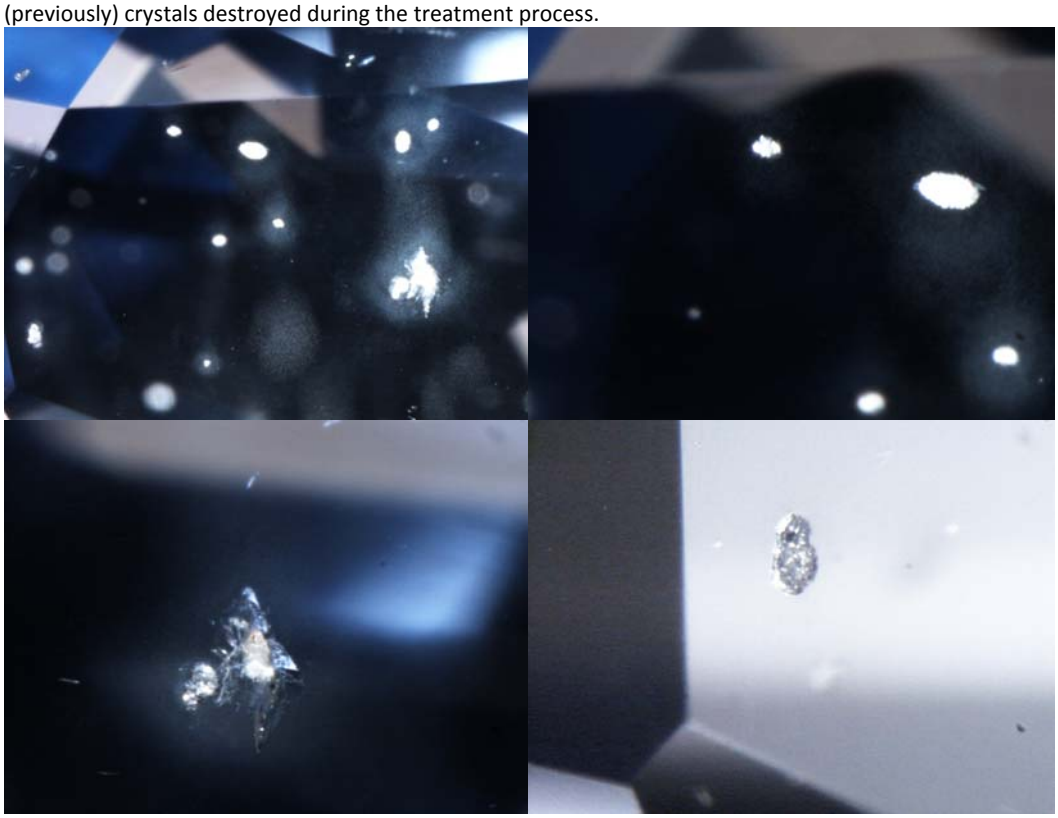

Figure 11: The inclusion scene within an oval 0.874ct (stone #2, Figure 5) Be treated blue sapphire revealing indications of high temperature heating. All images show the total destruction of individual (previously) crystals with top left and right, as well as bottom left showing that these are surrounded by fine clouds of pin-point inclusions (seen in reflected light from an optical fiber).

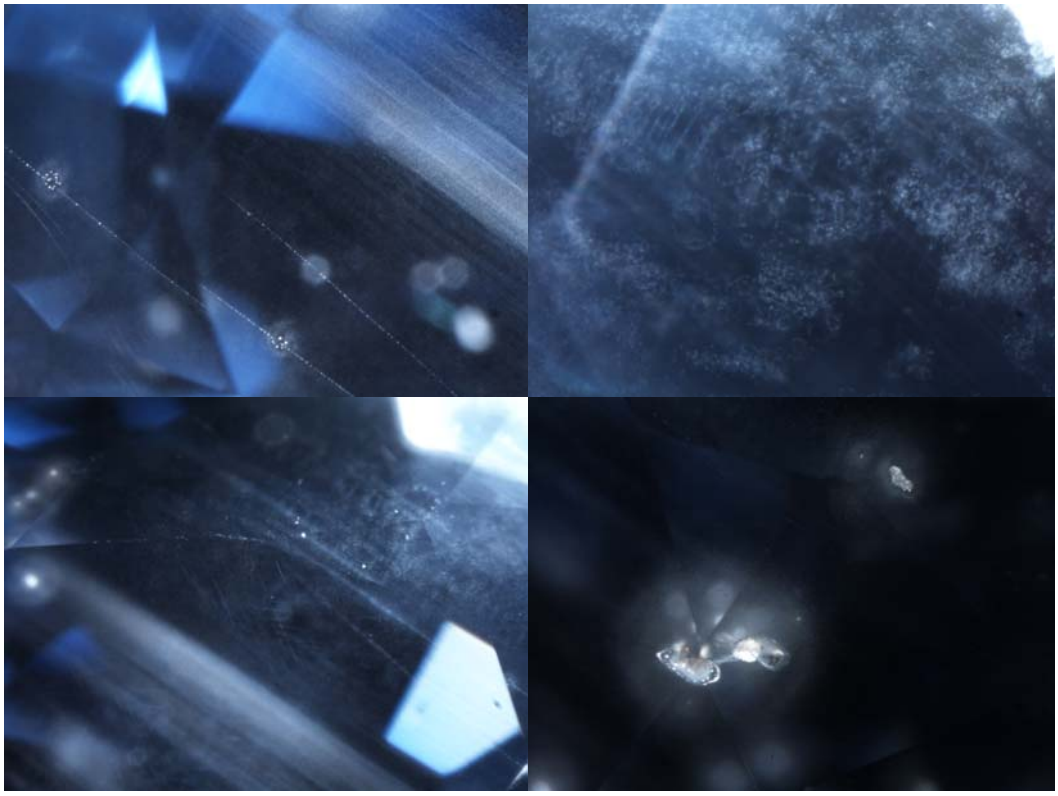

Figure 12: The inclusion scene within an oval 1.101ct (stone #3, Figure 5) Be treated blue sapphire revealing indications of high temperature heating. Top left traces of artificially healed tubes, top right and bottom left circular and indistinct coiled spring-like formations that have previously been reported as characteristic of Be treated blue sapphires. Bottom right, heat destroyed (previously) crystals surrounded by fine clouds of pin-point inclusions (seen in reflected light from an optical fiber) as seen also in Figure 10.

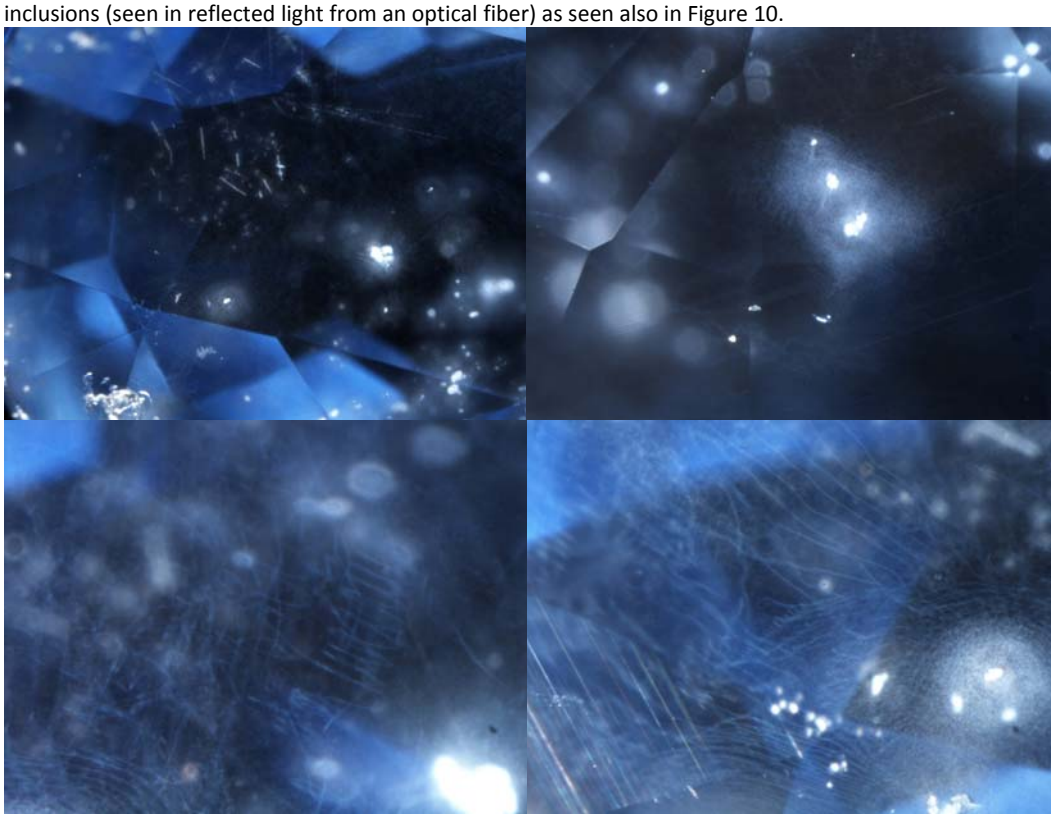

Figure 13: The inclusion scene within an oval 0.883ct (stone #5 Figure 5) Be treated blue sapphire revealing indications of a high temperature heating environment. This stone displays coiled spring-like and web-like formations (bottom left and right) reported as being characteristic of Be treated blue sapphires.

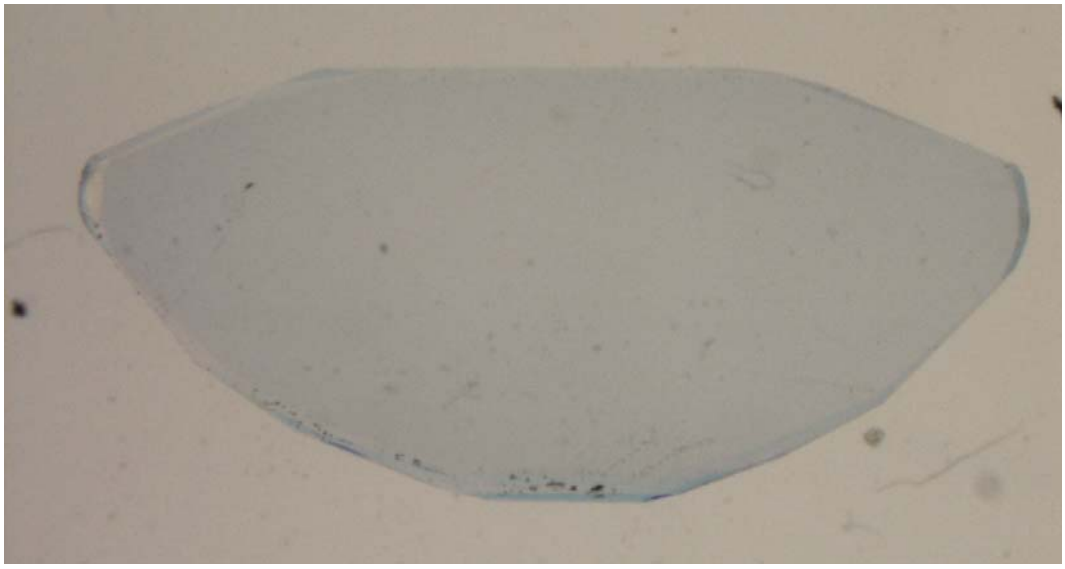

Figure 14: Stone number 4 after being polished to a thin slice (1.03mm), see here immersed in diiodomethane. No color zoning was observed, either in terms of natural growth or surface conformal (the white area top left and the gray area bottom right just inside the edge of the stone is related to remaining facet refection)

Color zoning

Each of the five Be treated blue sapphires (Figure 5 and Figure 14) were examined immersed in diiodomethane (RI 1.74) to observe any color zoning that may be present. No colorless rims as observed and reported by GAAJ (Kitawaki, 2006) (Figure 15) were found to be present in any of the five stones, and the slight discoloration from blue to gray at the rim described by Peretti (Peretti, 2005a) was also not observed in these samples. No other kind of surface conformal zoning was present in any of the stones, e.g., see Figure 14, and angular blue color zoning was observed only in stone #5. No blue color zoning was observed in stones 1 to 4 although straight brown (rutile) zones were noted in stone #3 as were brown halos surrounding destroyed crystals in stone #3.

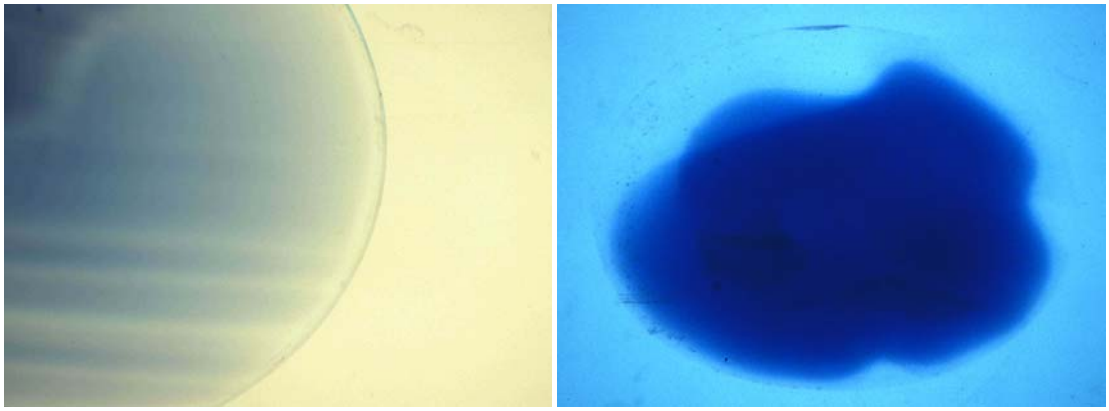

Figure 15: Colorless rims to heated blue sapphires in which Be was detected by researchers at the Gemmological Association of All Japan in July 2003 (left) where the rim appeared to be surface conformal and July 2004 (right) where the rim was not surface conformal. GAAJ. Photo ©GAAJ

Fluorescence:

All five stones were found to be inert to SW ultraviolet light but fluoresced red to varying degrees under LW ultraviolet light. This red fluorescence was recorded in greater intensity using the *DiamondView™* (The Diamond Trading Company) at 2.5sec integration, 16.00db gain and a full aperture at full power (Figure 16, Figure 17, Figure 18, Figure 19 and Figure 20).

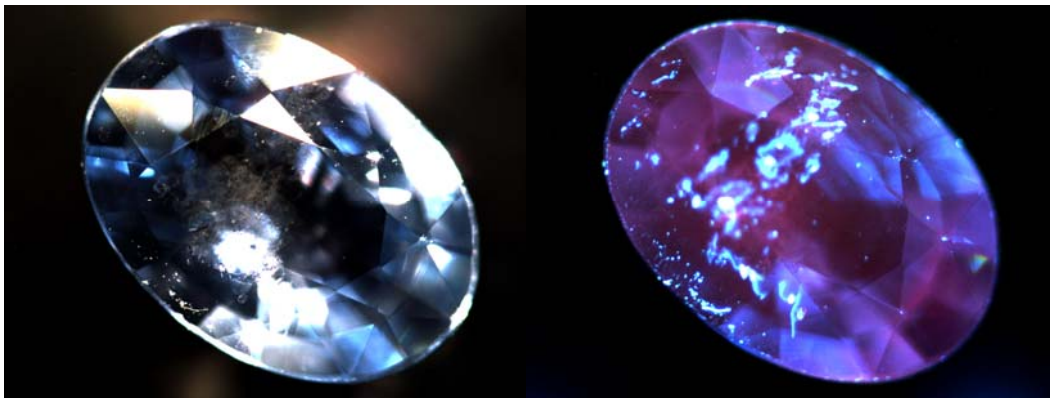

Figure 16: Stone number 1 (Figure 5) in normal light (left) and in the *DiamondView™* (right)

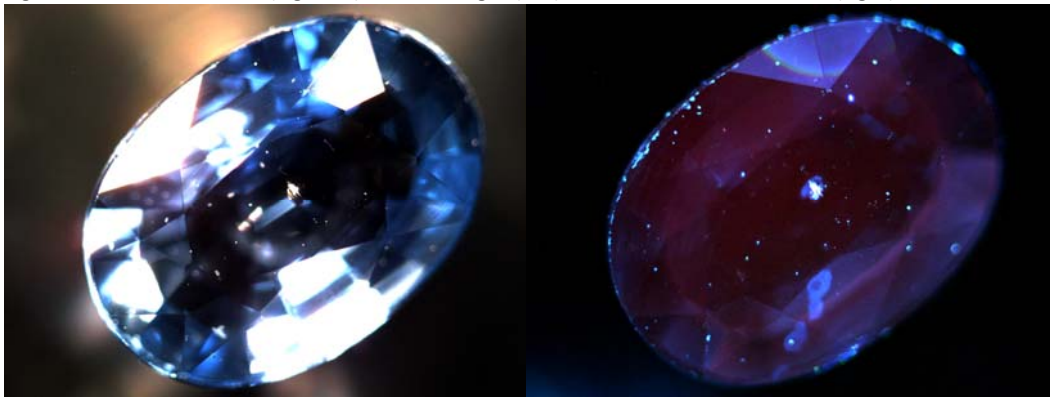

Figure 17: Stone number 2 (Figure 5) in normal light (left) and in the *DiamondView™* (right)

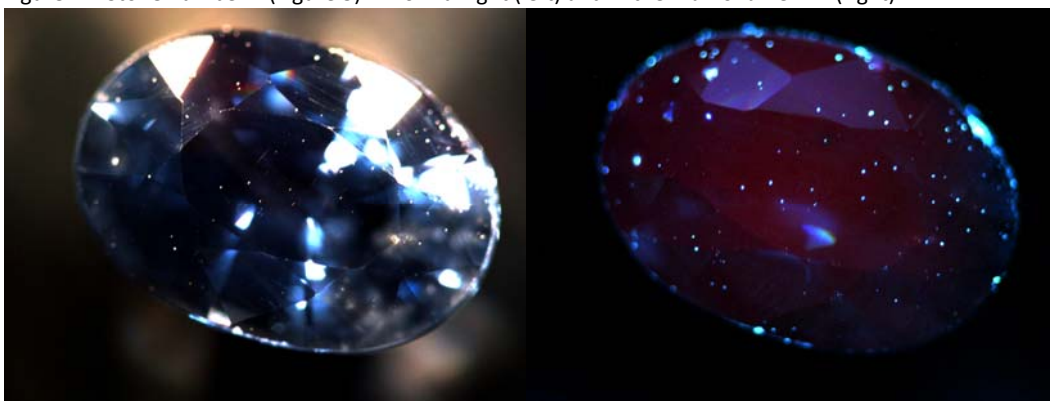

Figure 18: Stone number 3 (Figure 5) in normal light (left) and in the *DiamondView™* (right)

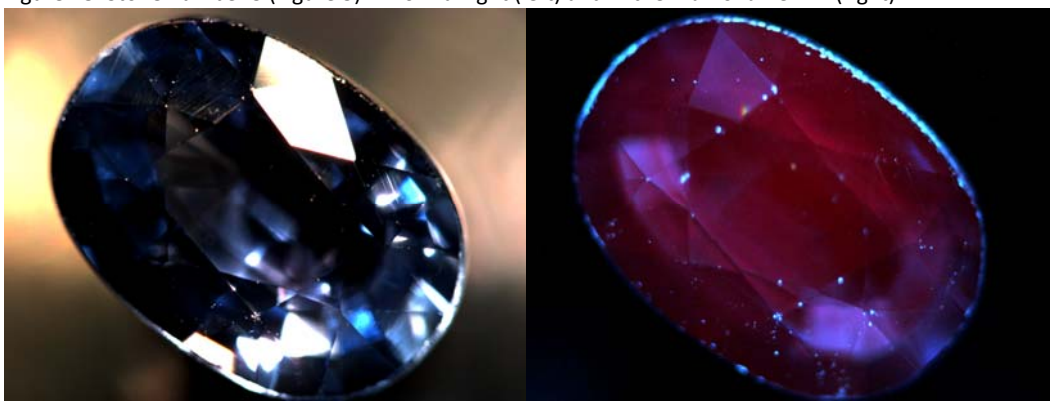

Figure 19: Stone number 4 (Figure 5) in normal light (left) and in the *DiamondView™* (right)

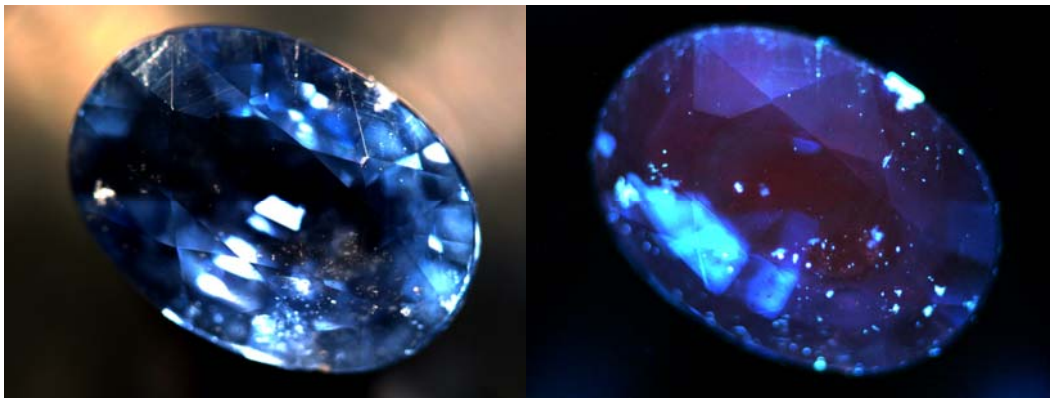

Figure 20: Stone number 5 (Figure 5) in normal light (left) and in the *DiamondView™* (right)

UV/visible and IR spectroscopy

The UV/visible spectra were recorded for both the O and E rays and may be compared in Figure 21, Figure 22, Figure 23, Figure 24 and Figure 25. The absorption edge is given arbitrarily for each spectrum at 9.5cm-1. It is interesting to note both the differences in apparent color of the samples (Figure 5) and the variables in visible spectra. The absorption edge varies from 298.5 to 310nm between the samples and the height of the shoulder at 330nm varies from approximately 1.25 to 3.5 cm-1. Stone number 3 (1.101ct), the darkest of the five, presented an entirely different spectrum to the other four with a relatively strong absorbance at around 880nm; it also contained the greatest amount of Fe (Table 2).

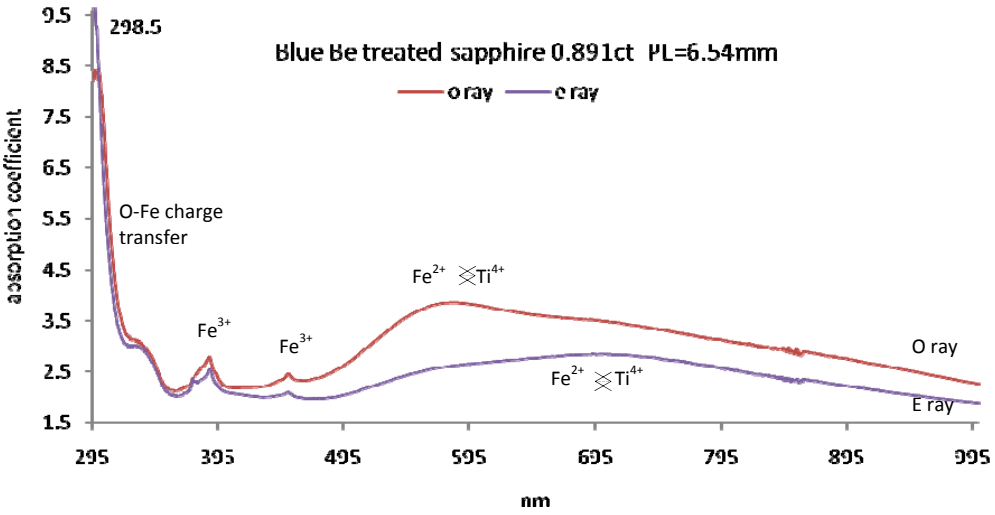

Figure 21: The absorption spectra obtained from an oval 0.891ct Be treated blue sapphire. The absorption edge is given arbitrarily at 9.5cm-1.

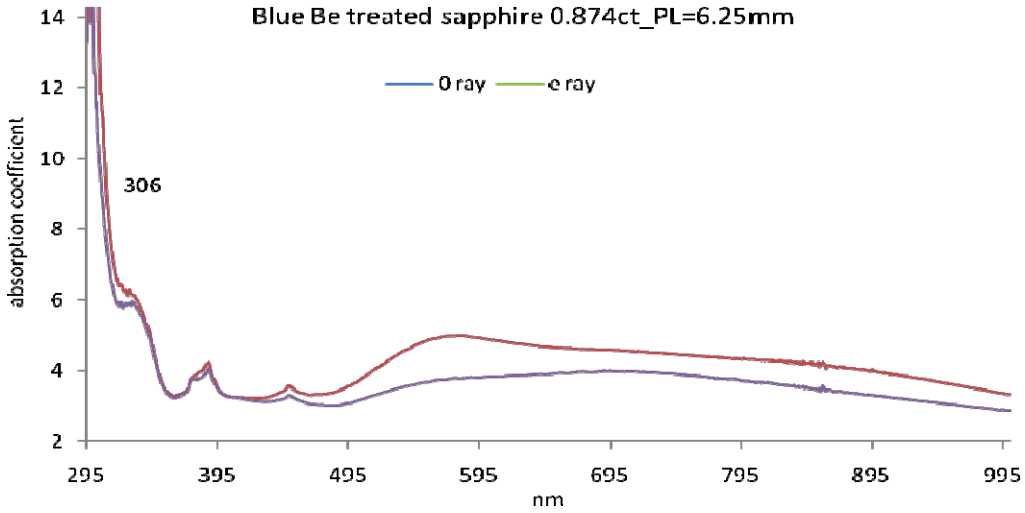

Figure 22: The absorption spectra obtained from an oval 0.874ct Be treated blue sapphire The absorption edge is given arbitrarily at 9.5cm-1.

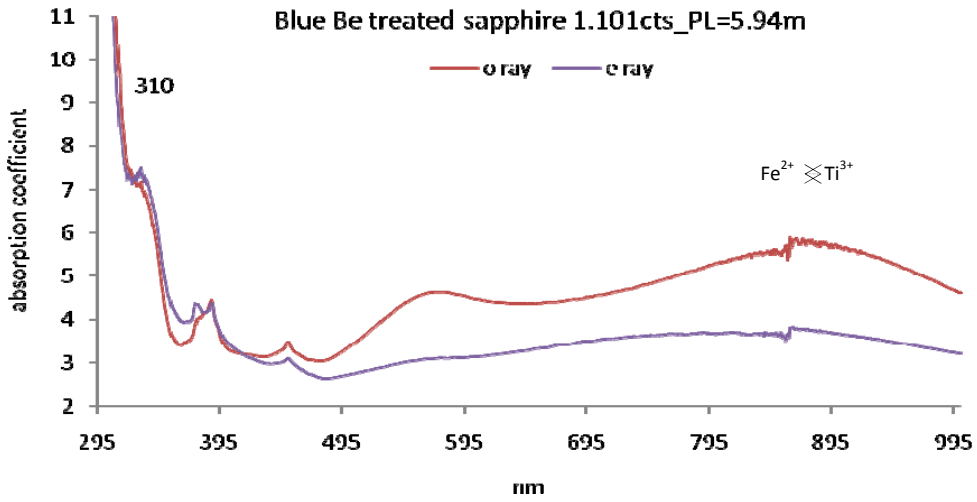

Figure 23: The absorption spectra obtained from an oval 1.101ct Be treated blue sapphire. The absorption edge is given arbitrarily at 9.5cm-1.

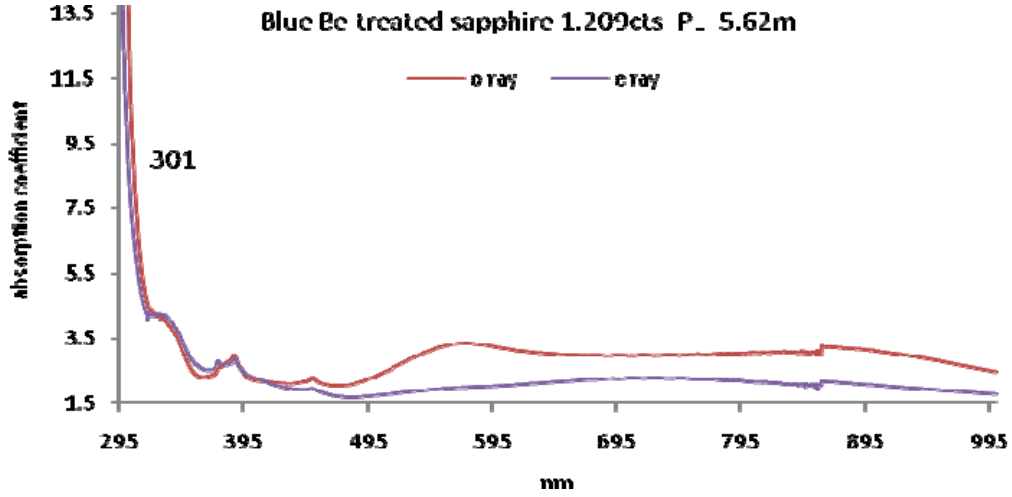

Figure 24: The absorption spectra obtained from an oval 1.209ct Be treated blue sapphire The absorption edge is given arbitrarily at 9.5cm-1.

DuToit, G., Thanachakaphad, J., Scarratt, K. (2009) Beryllium Treated Blue Sapphires: Continuing market observations and update including the emergence of larger size stones. June 25th 2009. *On-going Research,* http://www.giathai.net/lab.php

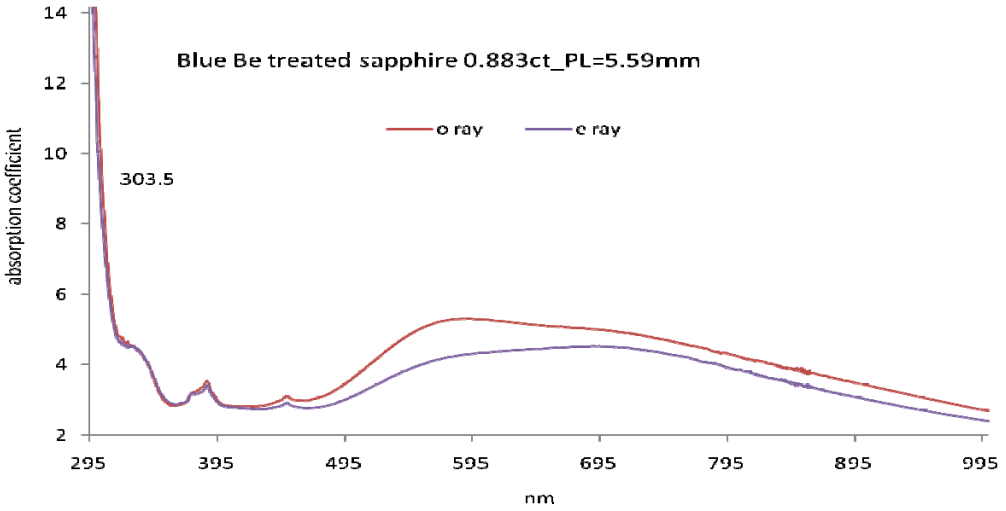

Figure 25: The absorption spectra obtained from an oval 0.883ct Be treated blue sapphire The absorption edge is given arbitrarily at 9.5cm-1.

In the infrared the only common point of interest in all five samples was the consistent presence of a peak located at 3209^{cm-1} ; the peak height varying from approximately 0.02 to 0.09cm $^{cm-1}$ (Figure 26). What this peak is related to is still uncertain although a similar peak is observed within the Punsiri-type spectrum recorded for the larger Be treated stones (Figure 33 and Figure 35) described later. Further spectra are presently being recorded on a larger number of similar sized Be treated blue sapphires in to establish whether or not this peak is consistent and possibly related to some element of the treatment process. Ahmadjan Abduriyim of GAAJ also confirms the presence of the 3209 peak in Be treated blue sapphires examined in Japan (Abduriyim, 2009).

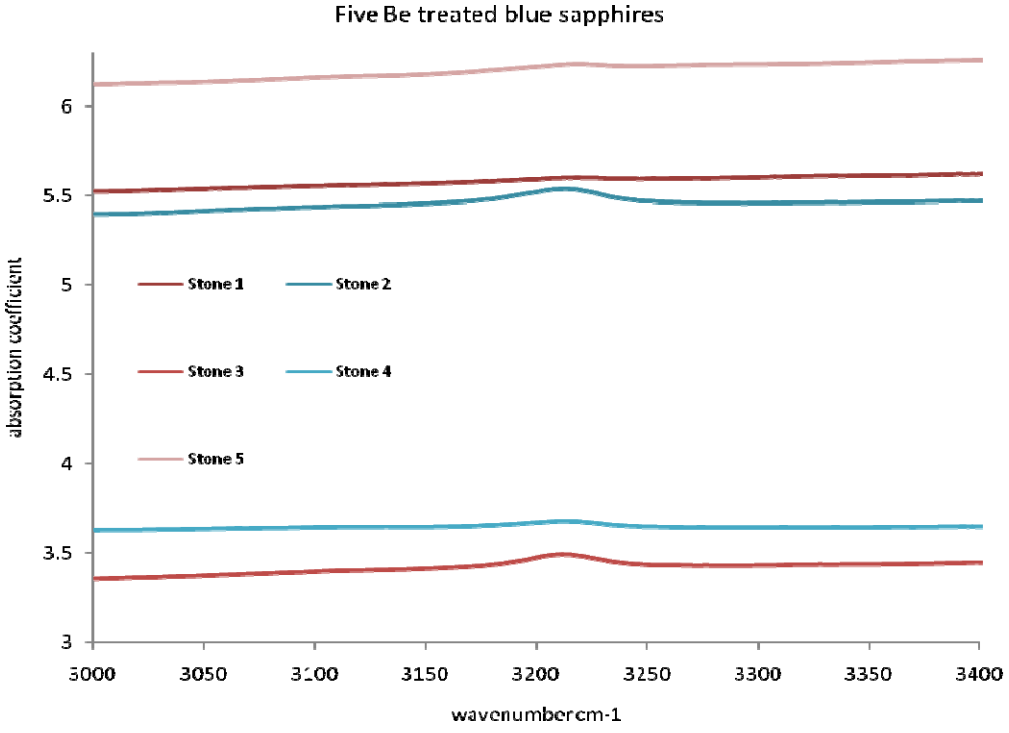

Figure 26: In the infrared spectra all five samples (Figure 5) a clear feature was recorded centered at 3209^{cm-1}.

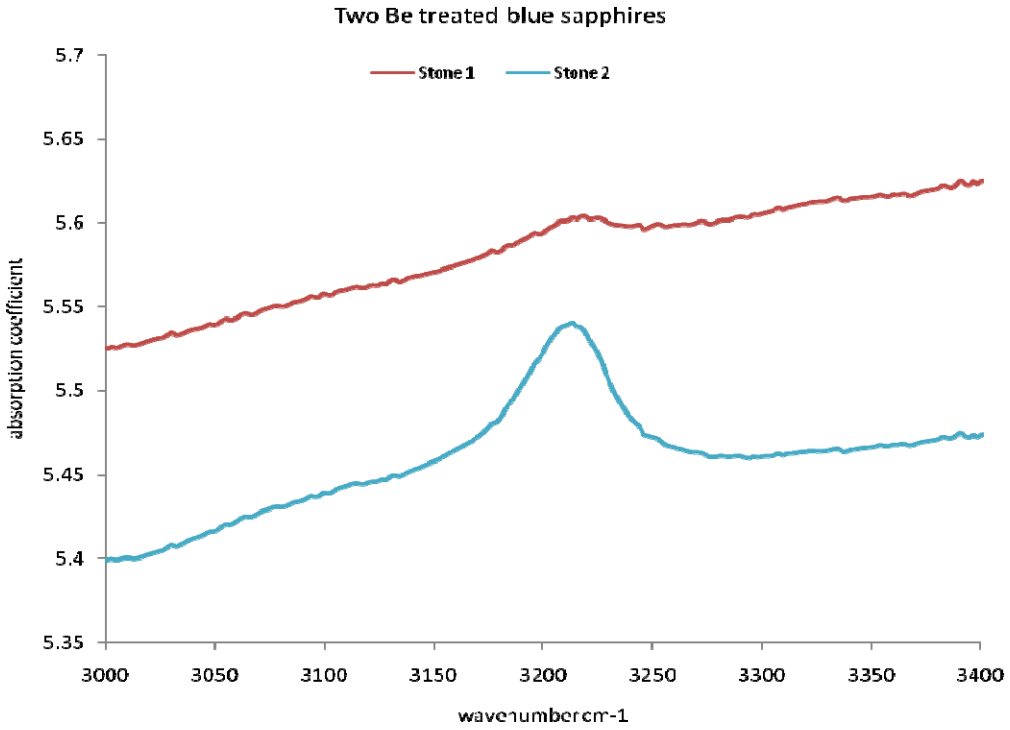

Figure 27: Greater detail of the 3209^{cm-1} in stone numbers 1 and 2.

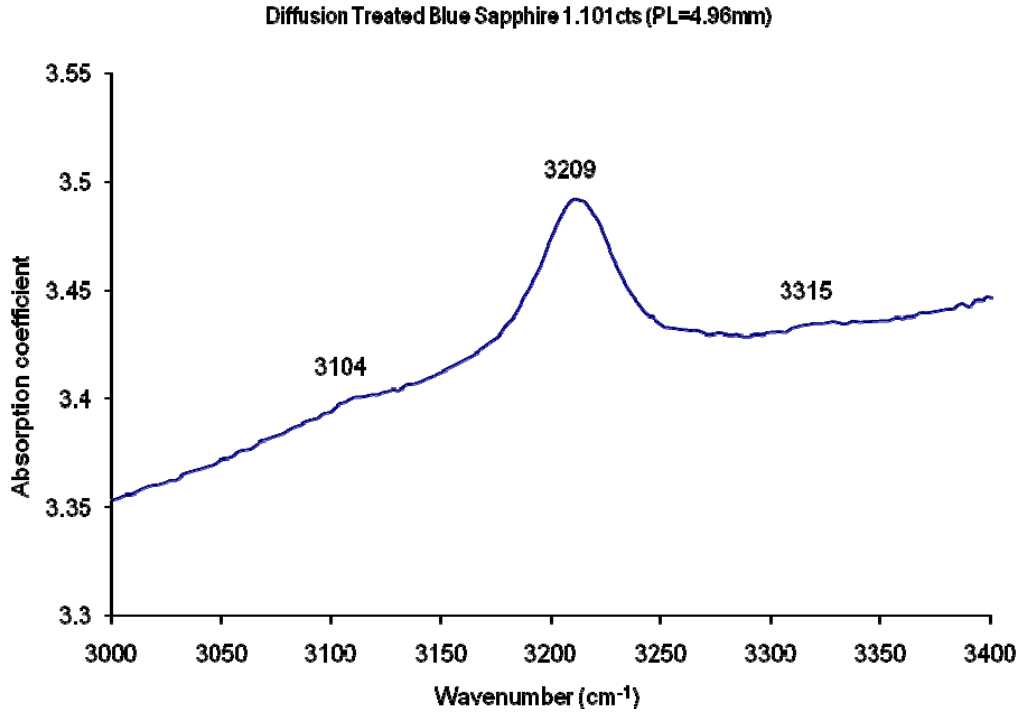

Figure 28: Greater detail of the 3209^{cm-1} in stone number 3 showing two small side bands at 3104 and 3315 $^{cm-1}$.

Two large beryllium treated blue sapphires

While they have been reported (Peretti, 2005a), large sizes in Be treated blue sapphires have only been rarely submitted to the laboratory for examination; so it was a little surprising when beryllium was discovered in the heated 22.52ct blue sapphire seen in Figure 1, and within a matter of days this was followed with the submission of the 55.88cts stone seen in Figure 29 where beryllium was also recorded. Further examination of the trace element composition providing sufficient information to conclude that in both cases the stones had been beryllium treated.

In the case of the second stone (55.88ct) it transpired that one of the owners actually treated the stone. He asked if we would like to visit him at his facility where we could talk about the "new beryllium treatment" technique he was using to produce these relatively large Sri Lankan blue sapphires. This meeting has taken place with relevant details of this and future planned meetings to be added to this paper at a later stage in the research process.

Beryllium and other trace element content

Upon receipt of each of these two stones (Figure 1 and Figure 29) it was firstly determined through a microscopic examination of their inclusion scenes (e.g., Figure 30, Figure 31 and Figure 32) that they were heated and as per procedure[2] their trace element composition was analyzed using LA-ICP-MS. Three spots were chosen for analysis on each stone and the results are set out in Table 5 and Table 7. Both stones were found to contain beryllium with the levels ranging from 7.50 to 18.17ppma. Other element levels were also recorded with Nb and Ta having no concentrations indicating that the beryllium had been added artificially during the heating process (Shen, 2007, Shen, 2009).

Figure 29: A 55.88ct beryllium treated blue sapphire.

[2] Procedure in such cases requires that heated corundum is analyzed using LA-ICP-MS and that in particular the concentrations for Be, Ta, and Nb are recorded.

Table 4: The Be concentrations (in ppma) in three spots examined on the 55.88ct Be treated blue sapphire depicted in Figure 9. Data collected by LA-ICP-MS

Sample	Be in ppma
53.88ct Be treated blue sapphire, spot 1	13.00
53.88ct Be treated blue sapphire, spot 2	17.12
53.88ct Be treated blue sapphire, spot 3	18.17

Table 5: Trace element concentrations (in ppma) in the 55.88ct Be treated blue sapphire depicted in Figure 9. Data collected by EDXRF

Sample	Ti	V	Cr	Fe	Ga
53.88ct Be treated blue sapphire	38.3	3.8	0.04	168.07	19.98

Table 6: The Be concentrations (in ppma) in three spots examined on the 22.52ct Be treated blue sapphire depicted in Figure 1. Data collected by LA-ICP-MS

Sample	Be in ppma
22.52ct Be treated blue sapphire, spot 1	7.58
22.52ct Be treated blue sapphire, spot 2	7.65
22.52ct Be treated blue sapphire, spot 3	9.46

Table 7 Trace element concentrations (in ppma) in the 22.52ct Be treated blue sapphire depicted in Figure 1. Data collected by EDXRF

Sample	Ti	V	Cr	Fe	Ga
22.52ct Be treated blue sapphire	84.67	3.20	BDL	53.45	21.15

Their chemistry was also analyzed using EDXRF [3] and the concentrations for Ti, V, Cr, Fe and Ga are listed in Table 6 and Table 8

Inclusion scenes

Both the 22.52ct and the 53.88ct beryllium treated blue sapphires are relatively clean internally. None of the inclusions typical of beryllium treated blue sapphires (Peretti, 2005a, Shen, 2007) as depicted in Figure 3, Figure 10, Figure 11, Figure 12 and Figure 13 are evident. Figure 30, Figure 31 and Figure 32 depict the only near surface and internal features present in the two stones; these features being indicative of heat treatment only.

[3] EDXRF (Energy Dispersive X-ray Fluorescence) is a fast technique used for bulk analyses where concentrations of elements Na and above are desired. The same standards are used both for EDXRF and LA-ICP-MS.

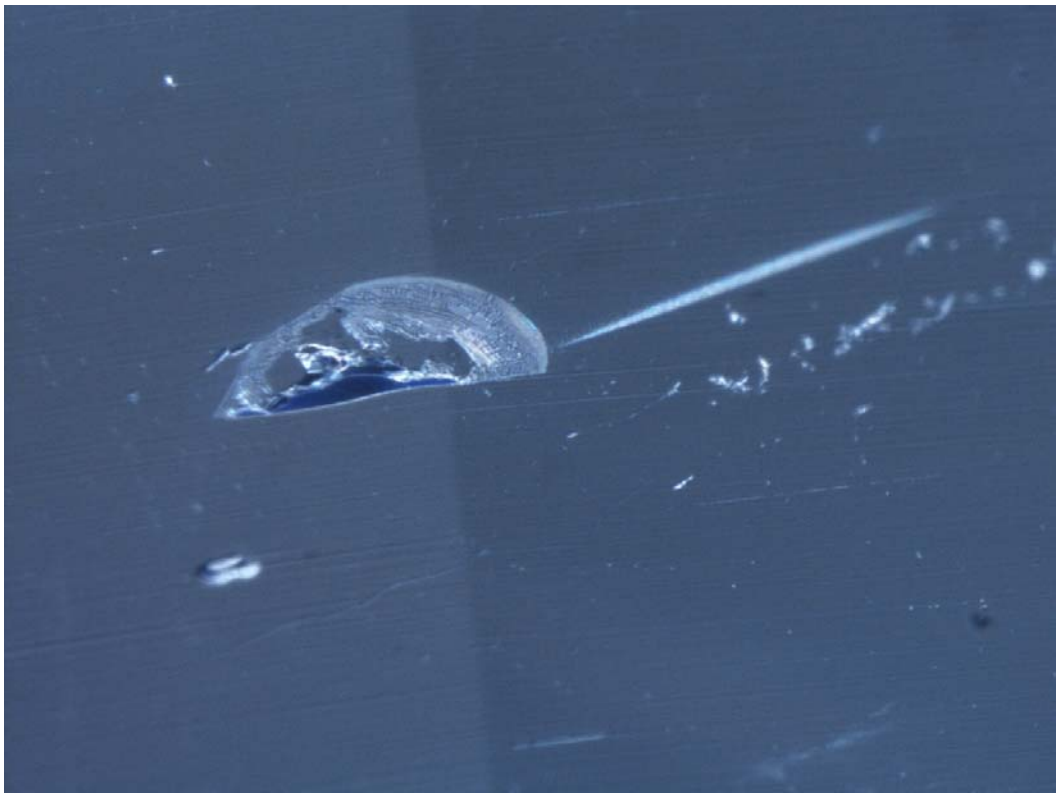

Figure 30: A surface-breaking heat altered healed fracture recorded in the he 55.88ct beryllium treated blue sapphire depicted in Figure 29.

Figure 31: Near surface 'feathering', a feature often associated with heated sapphires, recorded in the he 55.88ct beryllium treated blue sapphire depicted in Figure 29.

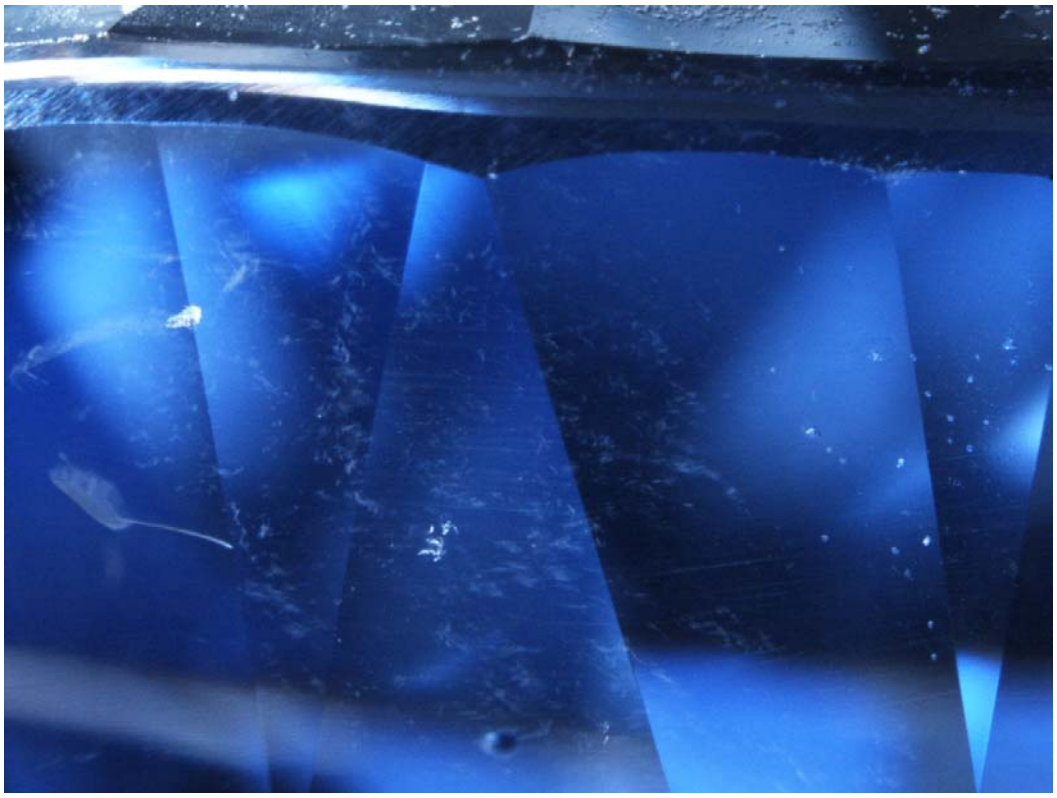

Figure 32: An image of the inclusion scene within the 55.88ct beryllium treated blue sapphire depicted in Figure 29. The stone is relatively clean internally and contained none of the inclusion types depicted in Figure 10, Figure 11, Figure 12 or Figure 13.

Fluorescence:

Contrary to the smaller stones described above both of these large stones were found to be inert to LW and SW ultraviolet light.

UV/visible and IR spectroscopy:

Given that these two large sapphires are 'production stones' rather than 'research stones' the amount of data collected is limited to the requirements of the report and achieving a reliable result. In cases where an identification of the stone (and any treatments) is the only requirement the collection of IR spectra is normal procedure, however, unless an origin determination is required the collection of UV/visible spectra is not normal.

For these two large stones the IR spectra were recorded with similar results. In addition to a peak at 3209 that is present in the five smaller stones described earlier (Figure 26), these large Be treated blue sapphires recorded broad peaks at 3112, 3057 and 2628 (Figure 33 and Figure 35). These spectra resemble the multiband structure seen in some Punsiri-type heated blue sapphires recorded in the past (AGTA-GTC, 2003, AGTA-GTC, 2004b, AGTA-GTC, 2004a).

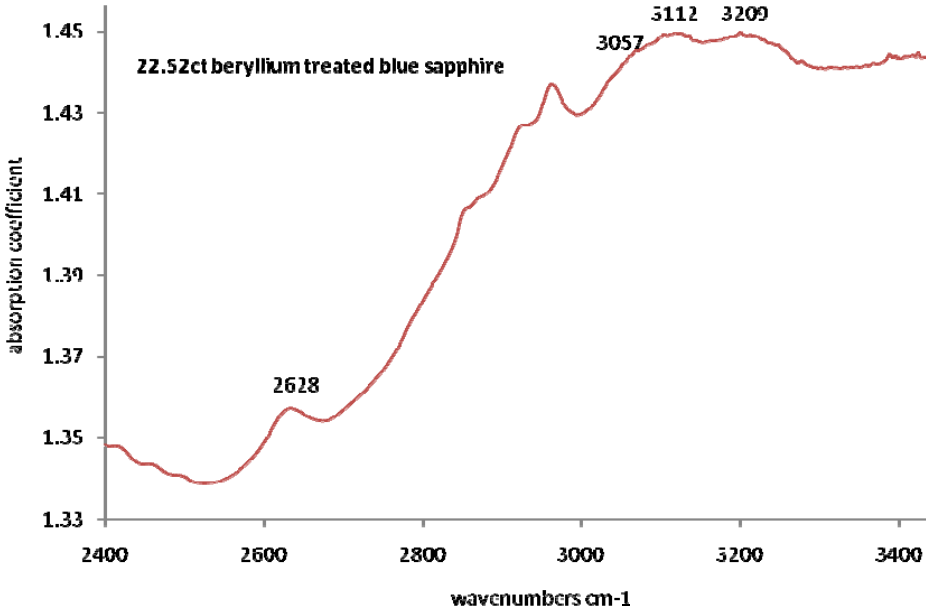

Figure 33: In addition to the peak at 3209 that is present in the five smaller stones described earlier (Figure 26), this 22.52ct Be treated blue sapphire has peaks at 3112, 3057 and 2628. Showing a strong resemblance to the multiband structure seen in some Punsiri-type heated blue sapphires recorded in the past and to that of the 53.88ct described herein (Figure 35).

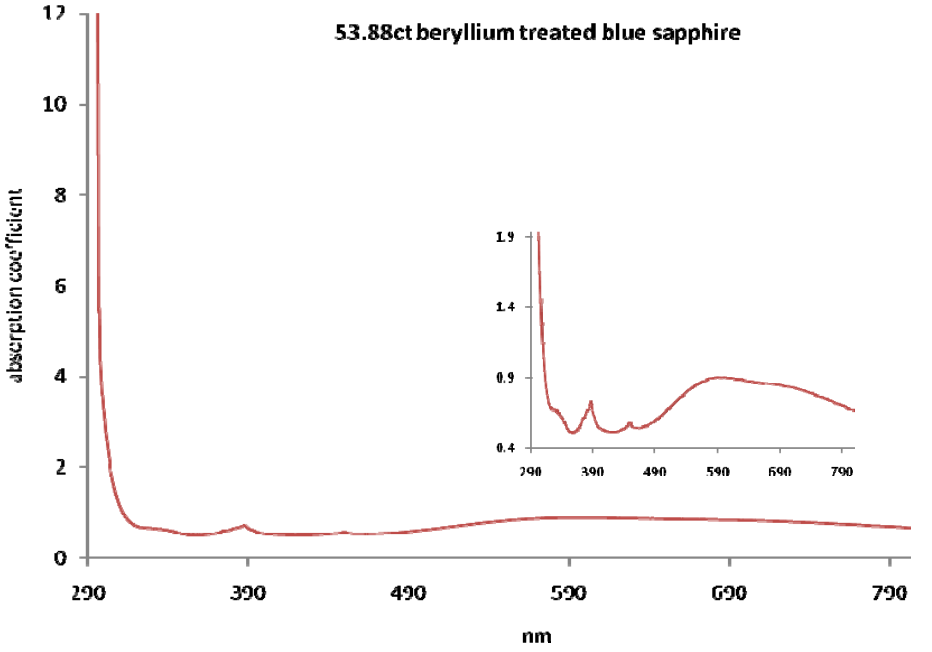

Figure 34: A mixed (O and E) ray spectrum of the 53.88ct beryllium treated blue sapphire depicted in Figure 29. The absorption edge at 9.5cm-1 is situated at 297nm.

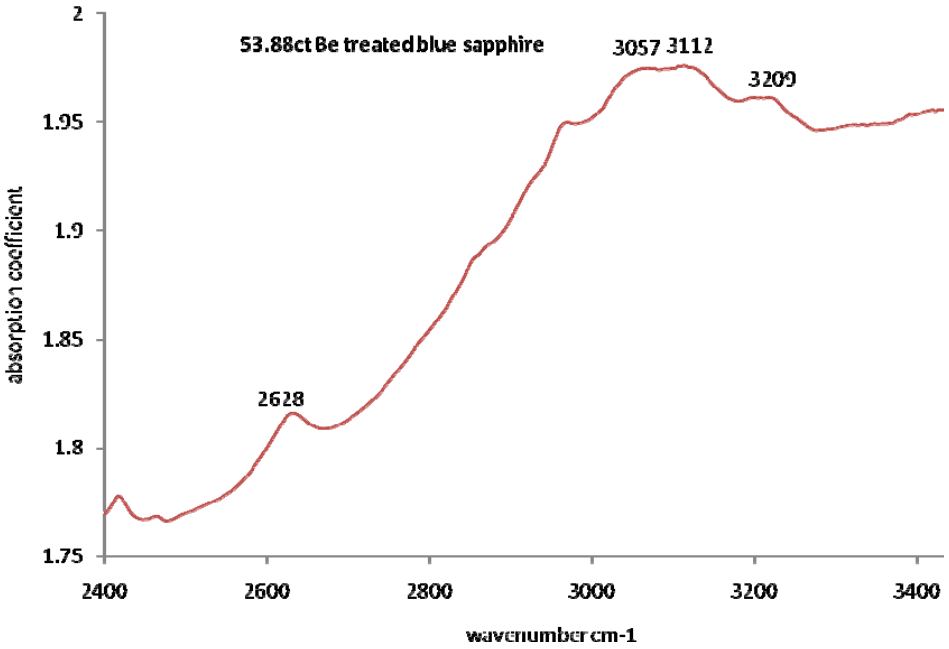

Figure 35: In addition to the peak at 3209 that is present in the five smaller stones described earlier (Figure 26), this 53.88ct Be treated blue sapphire has peaks at 3112, 3057 and 2628. Showing a strong resemblance to the multiband structure seen in some Punsiri-type heated blue sapphires recorded in the past and to that of the 22.52ct sapphire described herein (Figure 33).

For the UV/visible the only spectrum recorded was that for the 53.88ct stone. This was a survey spectrum (Figure 34) with no attempt made to record separate O and E rays. However, the spectrum is of the type one would expect from a Sri Lankan blue sapphire that has been heated. More detailed spectra of this stone type will be forthcoming as this project continues.

Discussion

The foregoing observations on beryllium treated blue sapphires constitutes a preliminary foray into an important area of gemstone treatment that, with the advent of large Be treated blue sapphires reaching the market, may require gemologists to examine more closely those stones that reveal any signs of heat treatment.

From the data obtained with this small group of stones, it would appear that a more rigorous approach to understanding of the processes involved and to the interpretation of results is needed to better understand the effects of Be diffusion in blue sapphire.

Unlike previous experiences with Be treated yellow, orange and smaller blue stones, the treater responsible for the larger sizes seems to be willing to share his technique / method with the authors and thus ushering in a rather refreshing era of greater transparency. Details of a more in-depth study of the technique and the before and after treatment materials will be added to this text in due course.

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