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Sciences behind gemstone treatments

New Blue-diffused Sapphires From Synthetic VS Natural Starting Materials

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Large quantities of a new blue sapphire diffusion-treated from a synthetic starting material have lately reappeared in the Chanthaburi market, Thailand since 2015. It is interesting to compare its gemological properties with those of a blue sapphire diffusion-treated from a natural material recently re-entered the market in 2012.

The synthetic stones (10 faceted-cut, 1.69-10.46 ct.) displayed strong varying blue color concentrations on different facets, along facet junctions and girdles due to faceting process, the so-called “spider-web effect” (Figure 1) under immersion (without Plato lines in crossed polars), uneven strong chalky blue fluorescence on different facets under SWUV, the presence of curved bands of minute particles or gas bubbles observed under microscope, the very high Ti (0.19-0.29 wt.%TiO₂), moderate Fe (0.07-0.20 wt.%FeO₂) but very low Ga contents (<0.01 wt.%GaO₃) on the stone surface by EDXRF, and no Fe³⁺-related absorption peaks on the UV-Vis spectra. These are the key characteristics to identify a blue-diffused sapphire of synthetic origin. The natural ones (33 faceted-cut, 0.90-2.06 ct. and 25 cabochon-cut 0.24-2.90 ct.), on the contrary, showed a vague “spider-web effect” (Figure 2), a weak chalky green-blue to inert under SWUV, the occurrences of tension discs, altered solid inclusions and altered fingerprints, often with color concentration along healed fractures and pits, the relatively high Ti (0.05-0.21 wt.%TiO₂), moderate Fe (0.05-0.41 wt.%FeO₂) and Ga contents (0.01-0.02 wt.%GaO₃) on the stone surface by EDXRF, together with some Fe³⁺-related absorption peaks on the UV-Vis spectra. These are the diagnostic features to confirm a blue-diffused sapphire of natural origin.

Even though both the synthetic and natural blue-diffused sapphires show the ‘spider-web effect’ under immersion, such effect in the natural stones is apparently much less pronounced as compared to that of the synthetic ones due to the difference of the thickness of the blue color rims. In fact, it was found by slicing the stones into a thin wafer that the thickness of blue color rim of the diffused natural stone (i.e., ~0.5-1.1 mm thick) was apparently much thicker than that of the diffused synthetic one (i.e., ~0.15-0.2 mm). Also with spot-traverse-analysis by LA-ICP-MS on the wafer surface, we found that the color rim thickness of the natural stone was coincided with the penetration depth of titanium, while that of the synthetic one was equal to the penetration depth of iron instead. In the case of the synthetic, in addition, not only Ti and Fe were found to be diffused from an external source into the stones, but also Be, Ga, Mn, and V were also infiltrated into the surface of synthetic colorless sapphire host. The colorless core area has insignificant amounts of other trace elements. As for the natural one, in contrast, Ti along with Be and Li were found to penetrate the stones while Fe, Ga, Mg, B, V and Cr contents were relatively constant throughout the slice section. The formation of the blue color rims in both synthetic and natural stones will be discussed together with the multi-element diffusion, other than Ti and Fe, found in those stones.

Figure 1: The blue-diffused synthetic sapphires (immersion), photo by P. Ounorn & S. Promwongnan

Figure 2: The blue-diffused natural sapphires (immersion), photo by T. Sripoonjan