KASHMIR SAPPHIRE

By **Dr. M.S. Krzemnicki, SSEF**

Nowadays, sapphires from Kashmir are among the most expensive and sought-after gems on the market. Just to highlight this, a Kashmir sapphire of 8.91 ct in a ring was sold in December 2012 at Christie's in New York for a record-breaking US$ 154,000 per carat. This trend is reflected in increased demand for gemstone origin reports from reputed gemmological laboratories such as SSEF.

△ **Figure 1:** The Star of Kashmir, a magnificent sapphire of 19.88 cts, certified by SSEF and to be auctioned at the May 2013 Christie's sales in Geneva.

There are several aspects that explain the appreciation for these sapphires in the market. Firstly, there is their apparent beauty (when we consider the stones of highest quality), composed of not only a vivid and well-saturated blue colour - poetically also described as cornflower blue – but also their slightly velvety appearance, which adds to the beauty of the colour of Kashmir sapphires. Secondly, there is a factor of rarity. The deposit near the village Sumjam on the southwestern slopes of the rugged Zanskar Range in Kashmir with its sapphires of high quality was only productive during a short period at the end of the 19th century (Mallet 1882, La Touche 1890, Atkinson & Kothavala 1983). Therefore, supply in the market is nowadays very limited (Hughes 1997). Take these two factors and add the often adventurous historical accounts of the discovery and mining of sapphires together with the descriptions of the Maharajas' fabulous gem collections from Kashmir, then you have the best ingredients to create high demand for this material in the market and a type of "luxury brand" for gem- and jewellery collectors.

Kashmir as a brand

Although Kashmir sapphires can be of truly exceptional quality and beauty, it has to be stressed that this "perfect image" of Kashmir sapphires is based on a rather small number of stones. As with any other gemstone deposit, we know that also this famed mining locality has produced a much larger amount of stones of lower quality. Therefore, the "origin label" Kashmir does not implicitly correspond to a high quality. It is the opinion of the author that it is still the apparent beauty of a stone that should remain the foremost criteria for valuation regardless of its origin.

However, it is a fact that new consumers, especially from emerging markets, are very much attracted to well-established brand names. Kashmir, along with a few other historic gem deposits (such as Burma for ruby and sapphire, and Colombia for emeralds, to name a few) have certainly become some sort of "brands" for consumers in the last few years. This is then reflected in the increase in price when well-documented stones from these sources are offered at auction or in the market, especially when supported by a report from a reputed laboratory.

Origin determination versus gambling

The Swiss Gemmological Institute SSEF has been at the forefront of origin determination of gemstones since nearly 40 years (Hänni 1990, Hänni 1994, Krzemnicki 2007). We have certified some of the most important Kashmir sapphires, including the "Star of Kashmir", which

will be auctioned at the upcoming Christie's sales in Geneva in May 2013. As origin determination has become such a price-sensitive issue for the trade today, we at the SSEF invest much time and effort to constantly update our scientific knowledge about these gems and to study all possible criteria for origin determination. There are two main fields of research. Firstly, the detailed characterisation of the Kashmir material itself. Secondly, by comparing Kashmir sapphires with material from other sources, such as Madagascar (Ilakaka, Andranondambo, Didy) or Sri Lanka (Elahera, Pelmadulla, Kataragama) to name but a few.

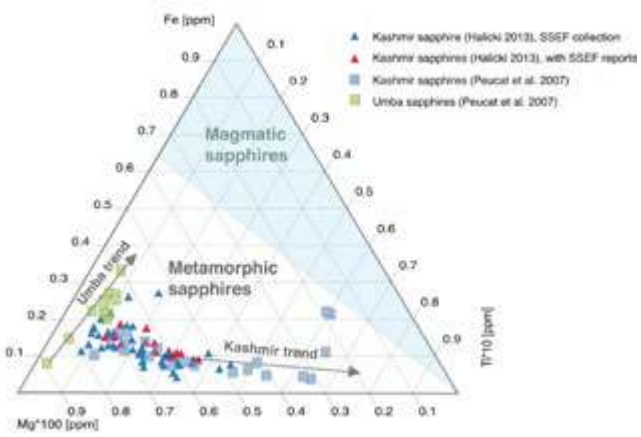
△ **Figure 2:** The Maharaja of Jammu and Kashmir, ca. 1900. © www.kashmirphotos.org/history.html

Even though many gem dealers have quite a good visual "feeling" to recognize Kashmir sapphires, it has to be said that many deposits produce sapphires of excellent quality which may resemble Kashmir sapphires in colour and velvety aspect. Thus, origin labelling based on these "soft" personal criteria is nowadays quite a gamble.

Inclusions in Kashmir sapphires

In the following, we present an insight into microscopic, spectroscopic and chemical criteria, which in combination, are used for origin determination of Kashmir sapphires at SSEF.

We can generally say that Kashmir sapphires are included. But, as many of these inclusions are very subtle and soft in appearance, they may even contribute to the visual beauty of these stones. The most marked feature is a distinct growth zoning, which usually results in a pattern of alternating transparent and slightly "milky" growth bands. These "milky" bands in fact contain numerous dispersed nanoparticles (Fe-Ti-oxides), which scatter the incoming light (Tyndall effect), thus resulting in a slightly bluish "sheen" adding to the blue colour produced by the colouring elements iron and titanium. This physical effect is in fact the same as when sunlight is scattered in the atmosphere, thus resulting in our blue sky. In minerals, this bluish sheen effect is better known from moonstones, where light is scattered on feldspar exsolutions and from blue quartz that contains asbestos-like fine tourmaline fibres.



△ **Figure 3:** Mg-Fe-Ti triplot showing the rather well-defined population field for Kashmir sapphires. For clarity reasons, the data of Sri Lankan, East-African and Madagascar sapphires have not been plotted. It has to be underlined that they do overlap the presented population field to some extent. Illustration adapted from Peucat et al. (2007) and Halicki (2013).

Apart from this, Kashmir sapphires may contain a large number of quite specific inclusions such as pargasite needles, short-prismatic dravite (tourmaline), corroded zircons, resorbed feldspars, and very fine patterns of crossing dust-tracks, dust clouds, and dust veils similar to the strokes of a brush (Gübelin & Koivula 1986, Hänni 1990, Krzemnicki & Halicki 2012). Although some of these inclusions are also known from sapphires from Sri Lanka or Madagascar, meticulous microscopic observations will show subtle differences in shape and clustering, thus providing valuable evidence for a formation outside of Kashmir. Even though microscopy is the most traditional approach for gemstone testing and origin determination, it is still nowadays one of the most powerful methods available. Inclusions are very sensitive markers for different geological settings, and in many aspects much more specific than some of the cutting-edge scientific methods (e.g. LAICPMS, UV-Vis, FTIR, EDXRF) that we have at hand today.

Chemical and spectroscopic properties

For sapphires, chemical trace element analysis (EDXRF, LAICPMS) will provide mostly supporting evidence for origin determination. In contrast to minerals such as beryl or tourmaline that have numerous structural sites of various sizes, corundum offers only restricted possibilities (most importantly a six-fold coordinated Al-site) for the incorporation of chemical impurities. This is mainly due to the dense crystal structure of corundum. From above, it is not astonishing that for emerald (variety of beryl) stemming from different geological settings, we know quite distinct chemical criteria for origin determination (e.g. V, Fe, Cr, Sc, Cs, Rb, Na, Mg), whereas in sapphires, the variability of possible trace elements is much more limited (due to size restrictions of the Al-site) and their concentrations are much more overlapping for stones from different sources (Peucat et al. 2007, Schwarz et al. 2008, Krzemnicki & Halicki 2012, Halicki 2013).

Nevertheless, we can say that Kashmir sapphires are generally characterised by low iron concentration and plot in a rather well-defined population field in the Mg-Ti-Fe triplot (see figure 3, adapted from Halicki 2013), as has already been stated by Peucat et al. (2007) and Schwarz et al. (2008).

Interestingly, the iron traces in sapphires from Kashmir is nearly fully ferrous (Fe^{2+}), with only very minor amounts of ferric iron (Fe^{3+}). This can be best observed in UV-Vis absorption spectra, where the peaks for Fe^{3+} at 450 nm and the doublet at 374 and 387 nm are nearly absent in Kashmir sapphires, compared to many other sources (see also Hänni 1994).

Raman spectra of inclusions are a further approach at SSEF to get valuable data for origin determination. For sapphires from Kashmir, there are several inclusions which are highly specific (pargasite, tourmaline, zircon), and which are analysed as a standard routine with our Raman system.

The Kashmir – Madagascar challenge

The supply of sapphires from new sources can be challenging, as they may strongly resemble the appearance of material from classic sources such as Kashmir. This is especially the case for sapphires from Madagascar, which may visually have a very similar velvety blue colour to that of material from Kashmir, and are thus sometimes mistakenly labelled as such in the trade. Other stones come with appropriate origin tags, but are further described as "Kashmir-type" on reports, a term which we at SSEF do not support, as we think it only causes confusion for the customer. Using this fancy term actually mixes two completely different concepts: 1) the geographical (and geological) origin of a material and 2) the perceived and subjective visual appearance.

Whenever we receive a sapphire for testing at SSEF, a first microscopic investigation is carried out to gather indications for possible origins as early as possible. Luckily, a comparison of internal characteristics between sapphires from Kashmir and similar looking sapphires from Madagascar often reveals subtle but nevertheless valuable differences. This is especially the case when comparing the arrangement of fine exsolution particles ("dust") in sapphires from these two sources. In sapphires from Madagascar these "dust" patches and tracks are quite distinct with a well-defined (rhombic) outline and (rhombohedral) arrangement, compared to a much looser and softer roundish pattern in Kashmir sapphires. Furthermore, in comparison to stones from Kashmir, Madagascar sapphires show much denser colour- and growth zoning that often dominates the stone along one direction.

The photos presented here should give an impression of the subtle differences in sapphires from these two origins. It also underlines the importance, still nowadays, of internal features for origin determination. However, one requires more than a simple loupe to be able to see and correctly describe these features. Interested readers are referred to our Advanced Training Course on Coloured Stones (4-8th November 2013), where such subtle internal features are presented and their relevance for origin determination are discussed in depth.

This article is an extended version of a lecture that was presented at the Seminar of the Gemmological Association of Hong Kong GAHK during the Jewellery Show in Hong Kong in June 2012 (see also SSEF website for a pdf download). ✶

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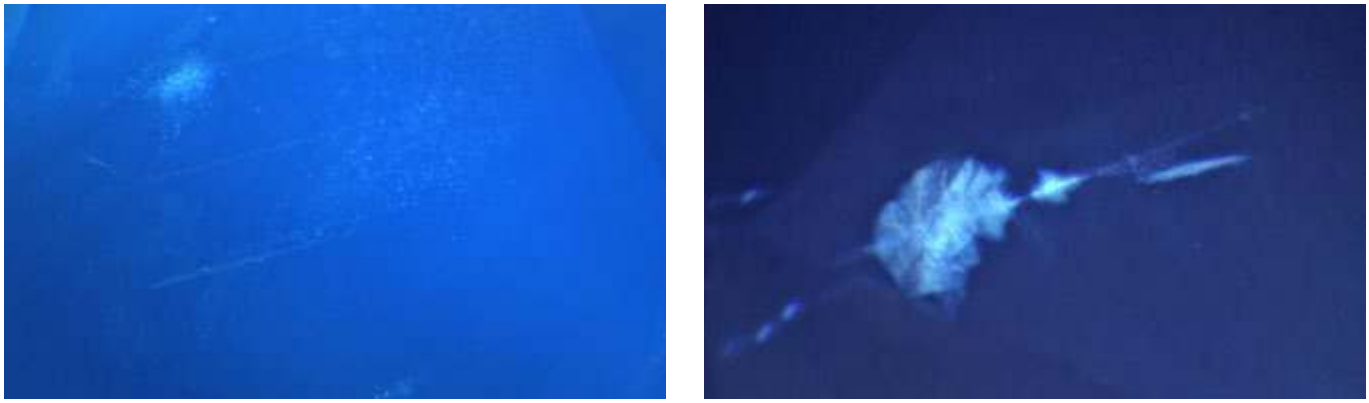
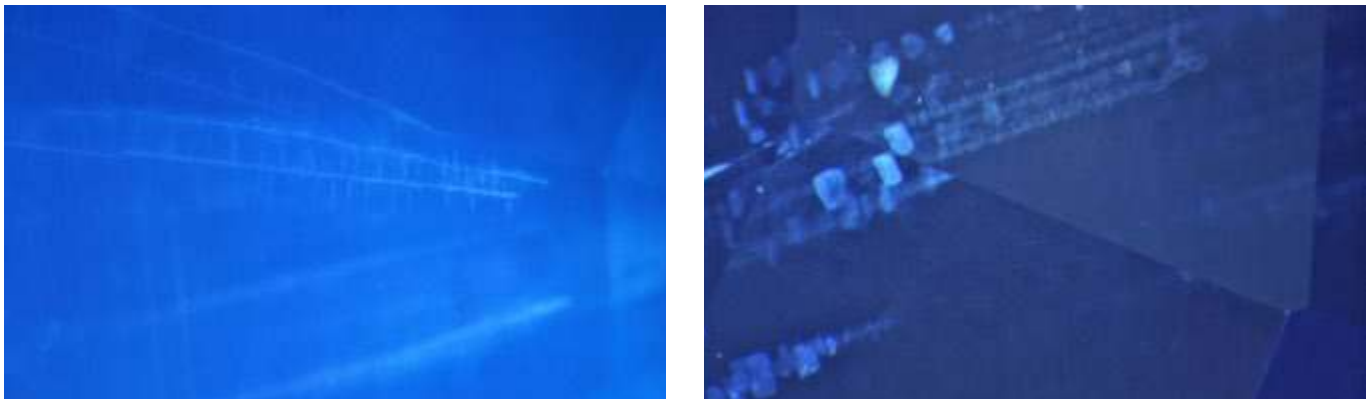
Comparison of internal features from Kashmir sapphires (left) and Madagascar sapphires (right).
Photos by M.S. Krzemnicki unless otherwise stated

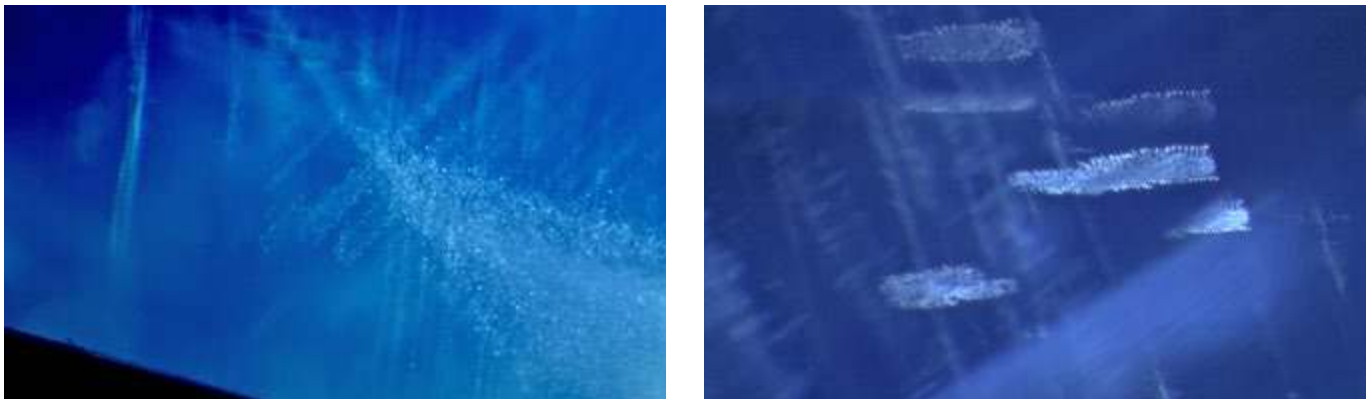


△ **Figure 4a**: Roundish loose patches of "dust" in Kashmir sapphires compared to well-defined rhombic patterns in Madagascar stones (left photo by H.A. Hänni, SSEF).

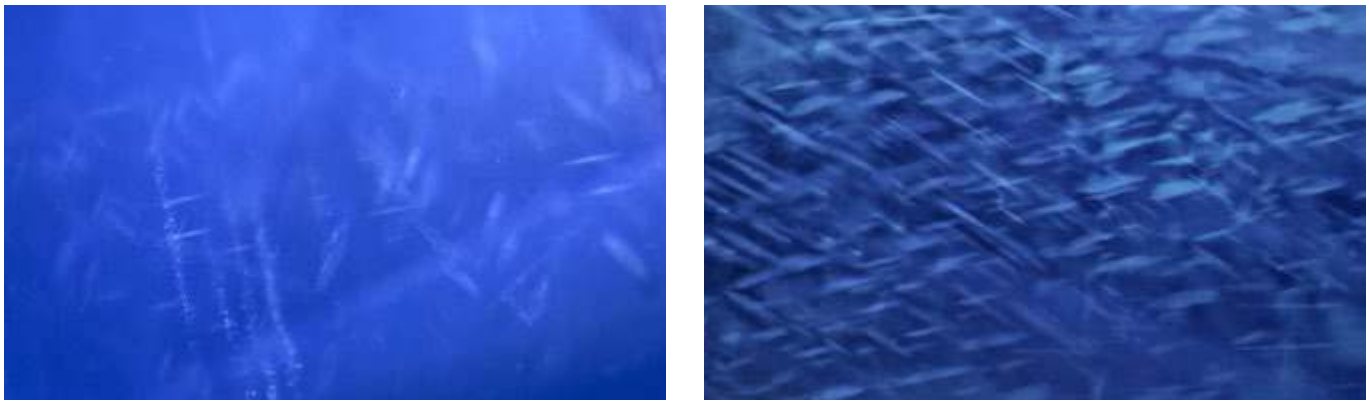
△ **Figure 4b**: Blocky "milky" zoning in Kashmir sapphire, compared to very dense zoning with a dark (nearly black) colour zone in a sapphire from Madagascar (left photo by H.A. Hänni, SSEF).



△ **Figure 4c**: Fine "dust" lines with brush-strokes in Kashmir sapphires compared to straight dust lines with defined patches in Madagascar stones (left photo by H.A. Hänni, SSEF).



△ **Figure 4d**: Crossing exsolution particles tracks and slightly curved dust lines in Kashmir sapphires compared to "millipede"-like structures and patches in Madagascar stones.



△ **Figure 4e**: Whereas the arrangement of these patches seems quite soft in Kashmir sapphires, it tends to be very much oriented along rhombohedral faces in stones from Madagascar (left photo by H.A. Hänni, SSEF).