Facette

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EMERALD CLEANING / RARITIES / JADEITE JADE
GEMTOF / AGE DATING / PEARLSCAN / SSEF AT AUCTION
SSEF COURSES / SSEF IN ASIA / ON-SITE TESTING

SSEF
SCHWEIZERISCHES GEMMOLOGISCHES INSTITUT
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Dear Reader

I am very proud to present you the 23rd issue of the SSEF Facette, the annual magazine of the Swiss Gemmological Institute SSEF. It again summarises our latest research findings about coloured stones, diamonds and pearls, and is also filled with information about education at SSEF, new client services, and new products.

The past year was very exciting in terms of new achievements at SSEF, but also challenging due to an economic situation resulting in rather slow business in all gem markets worldwide. Having anticipated this economic trend, I am very glad to say, that SSEF has been successful not only in Switzerland, but also especially active during our on-site testing periods abroad. Our aim with on-site testing is to bring our gemstone and jewellery testing services as close as possible to clients in an efficient manner. We will continue and even offer more such on-site services to you in 2017.

The main analytical achievement at SSEF in 2016 was the successful integration of GemTOF, a next-generation elemental technique using a Time-Of-Flight mass spectrometer (yes, the same method as used on the Mars rover and other space missions !). This highly versatile instrument provides us with new and substantial data for origin determination and treatment detection mainly. It also proves our commitment to constantly investing in state-of-the-art equipment with the aim of offering our clients a service of the highest quality and scientific standard. Interested readers will find detailed explanations about this new method in a featured article in this SSEF Facette.

Regarding pearl testing, I am very proud to announce that we are able to now offer age dating of pearls - a topic of research at SSEF since many years - as a novel service to our clients.

The SSEF Facette, born as a four page typewritten leaflet baby has now even outgrown its teenage phase. With the current 23rd issue, it has truly entered its twenties, and it seems to get stronger every year in weight, volume, and scientific content, always with the aim to capture your interest in our gemmological research or just for your reading pleasure.

In this spirit, I wish you a very successful and exciting business year in 2017 but also some private time to reflect on the beauty which passes through your hands through your profession - gems and jewels, treasures of nature - and the human stories behind it all.

Dr. Michael S. Krzemnicki
Director SSEF

M. Krzemnicki

COVER PHOTO ▷

Miner at Mwarasi ruby deposit in Tanzania

Photo: M.S. Krzemnicki, SSEF

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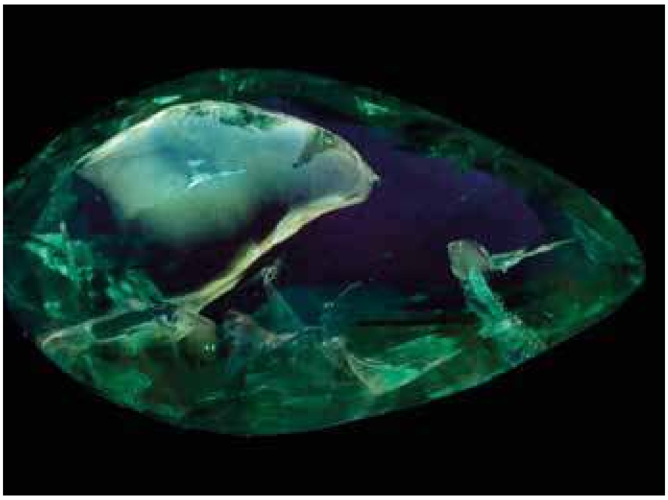
EMERALDS AND THE SAGA OF CLEANING AND FILLING FISSURES

Emerald, the green chromium-bearing variety of beryl $Be_3Al_2(Si_6O_{18})$, has been highly valued as a gemstone since historic times. Emeralds are known to contain often quite large amounts of inclusion features, such as fluid and solid inclusions and fissures, poetically also known as 'the garden' of emeralds. Especially in emeralds from Colombia, such features can be very prominent (Ottaway et al. 1994) and reduce the transparency – and thus beauty and value of the gemstone considerably. There is a long established tradition in the trade to fill open fissures in emeralds with colourless fillers (Figure 1), such as oil, wax and (artificial) resins, to reduce their visibility (Ringsrud 1983, Kiefert et al. 1999).



△ **Figure 1:** Fluorescent reaction caused by the oil present in the fissures of an emerald. Photo: M.S. Krzemnicki, SSEF

Disclosure of such treatments is mandatory (CIBJO), including a quantification of the filler substance, as this may have a direct impact on the pricing of an emerald. To harmonise the wording, the SSEF together with the other members of the Laboratory Manual Harmonization Committee (LMHC) developed in 2007 a common wording to describe the amount of filler in fissures of emeralds (see www.lmhc-gemology.org/pdfs/IS5_23092010.pdf).

The current trend in the high-end trade is to prefer emeralds containing only oil (e.g. cedarwood oil) and no artificial resin (e.g. opticon) in fissures, as oil is considered the most traditional way of enhancing the clarity of an emerald. As a consequence, many emeralds originally fissure-filled with artificial resin are cleaned chemically and eventually refilled later with oil, so that the visibility of the fissures remains reduced. This poses some problems, as a refilling of fissures is very easy and fast and can thus be done in a few minutes at any time, even after it has been tested by a gemmological laboratory.

New Wording on SSEF Reports since March 2016

As a consequence, we have adopted since March 2016 a new and more descriptive way to describe the clarity modification of emeralds on our reports. We have to remind our clients however, that any statement on a gemmological report always refers to the situation at the time of testing.

We distinguish three cases:

1) Emeralds with no fissures (very rare): As there are no fissures at the time of testing, these emeralds cannot and are not clarity enhanced by a fissure filler at the time of testing. In such a case, we will state on our report: **No indications of clarity modification at the time of testing**

2) Emeralds containing fissures, but without any clarity modification by a fissure filler are described as follows: **No indications of clarity modification in fissures at the time of testing.**

This is to express that this emerald contains fissures, which should be eye-visible even to an untrained observer. Any such emerald may be refilled at any time after we have issued the report (Figure 2). We therefore strongly urge our clients to have such emeralds rechecked by SSEF before buying the gemstone, especially if the report is not a very recent one and if the emerald looks very clean without any visible fissures.

△ **Figure 2:** Colombian emerald which has been thoroughly cleaned (on the left) and which thus shows prominent fissures. After refilling these fissures with cedarwood oil, the apparent clarity of the same emerald (on the right) has distinctly improved. Both situations were analysed by SSEF and each time a report was issued, documenting the situation (first none, then moderate oil) at the time of each testing. Photo: L. Phan, SSEF

3) Emeralds which do contain fissures containing a filler substance for clarity modification are described as follows: **Indications of clarity modification. Minor (or moderate, significant) amount of oil (or artificial resin etc.) in fissures at the time of testing.**

The SSEF is one of the very few laboratories, which discloses the nature of the filler substance in emeralds. This identification is mainly based on infrared spectroscopy and Raman microspectrometry, combined with meticulous microscopic observations (Kiefert et al. 1999). Since many years, we do not offer our clients anymore the option to choose whether the identity of the filler substance is mentioned or only quantified as 'filler'. This is in line with our full disclosure policy with the aim of fully informing our clients but also the final consumer of the treatment status of a gemstone at the time of testing at SSEF.

The scheme of the cleaning and filling saga:

The new wording is also a measure against the fraudulent use of SSEF reports in cases where emeralds are refilled with oil (or artificial resin) after we have issued a report for a previously untreated and clean stone.

The scheme of such fraudulent use of gemmological reports (not necessarily only of SSEF reports) usually starts with an emerald containing artificial resin to hide its fissures. The stone is then thoroughly cleaned using chemicals until no filler is detectable anymore in the fissures. After this cleaning process, the emerald - now often showing prominent fissure features - is then submitted to a gem laboratory for testing, and eventually receives a testing report which indicates that no clarity modification was found. To be attractive and saleable, the same emerald often urgently needs some clarity enhancement after the forced cleaning. Its fissures are therefore again filled with a colourless filler (commonly with oil). This is no problem as long as a new report is made stating the new treatment status of the emerald.

But it is also obvious from the above that selling an emerald which has been refilled but is still accompanied with the now outdated 'no oil' report is fraudulent.

In the last few months, we have analysed a few emeralds which have been refilled - unintentionally or intentionally - but which were still accompanied with a SSEF report of the previously clean stone and thus indicating no clarity modification. Apart from being a nuisance to us and our clients, such cases are also threatening the trade as it may strongly undermine the confidence of consumers in emeralds and finally in the jewellery trade. This situation has led us to change our wording as detailed above to describe the clarity modification of emeralds (and any other gemstone). We are convinced that the new wording on our reports is adding 'clarity' to this complex matter and helps to prevent fraudulent use of our reports.

Finally, we would like to remind our clients, that any comment on an SSEF report always indicates the opinion of the laboratory at the time of testing. We thus strongly recommend to first check the authenticity and validity of a SSEF report on www.myssef.ch (for SSEF reports since March 2009) and/or to have its current treatment status rechecked by SSEF, especially in case of emeralds with fissures, which may be filled so easily and fast. ✶ **Dr. M. S. Krzemnicki, SSEF**

△ **Figure 3 :** Example(s) of the new wording on SSEF Reports for emeralds.

RARITIES AND COLLECTOR STONES TESTED RECENTLY AT SSEF

The daily routine at SSEF usually consists of testing rubies, sapphires, emeralds, pearls and diamonds. Although sometimes challenging and interesting, especially taking into account the quality and the documented historical provenance of some of these gems and jewellery items, it is also always of great interest and scientific value for us to analyse rare minerals and collectors stones, which are occasionally sent to SSEF. In the past few months, we have been especially fortunate to analyse and document an eclectic mix of such gems, a few of them that will be presented in the following.

A rare collection of pezzottaite

Pezzottaite is a rare and attractive pink mineral which was discovered only in 2002 in a few pegmatites in Madagascar, Afghanistan and lately the Mogok Stone Tract in Myanmar. This mineral bears a close structural relationship to beryl, however it shows a trigonal crystal structure due to the ordered substitution of part of beryllium by lithium, coupled with caesium in its channel structure (Hänni & Krzemnicki 2003 & 2004, Laurs et al. 2003). Named after Dr. Federico Pezzotta, it immediately drew the attraction of gemstone collectors due to its attractive pink colour, sometimes additionally highlighted by a distinct cat's-eye effect.

Recently, the SSEF had the opportunity to investigate an impressive collection of more than 20 faceted pezzottaites ranging in size from 100 ct to 6 ct (Figure 1). The gemstones were readily identified based on their elevated Cs concentration and characteristic Raman spectrum (Hänni & Krzemnicki 2003; Lambruschi et al. 2014). Having analysed a number of rather small specimens just after the discovery of this new mineral in 2003, we were stunned to see a collection of such large faceted pezzottaites. Due to their outstanding size, they perfectly displayed their distinct pleochroism when observed in different orientations (Figure 2). Not to our surprise, a detailed study with FTIR and Raman revealed that the fissures present in these pezzottaites were filled with colourless artificial resin and oil to enhance their clarity.

◁ **Figure 1**: Collection of pezzottaites - rare collector stones - ranging in size from 100 ct to 6 ct, which was analysed recently at SSEF. Photo: SSEF

◁ **Figure 2**: Pezzottaite is characterised by a distinct reddish to purplish red pleochroism. Photo: SSEF

Rare twins: Musgravite & Taaffeite

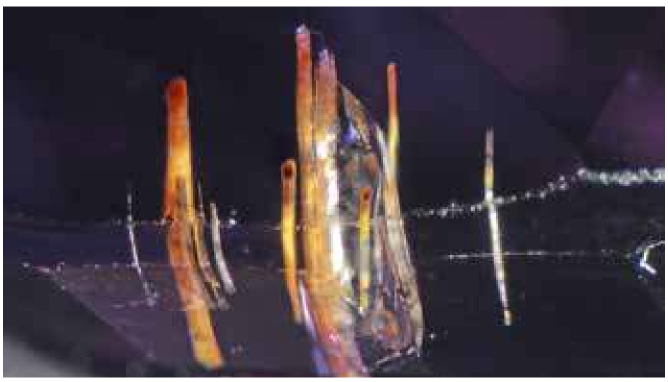
Having analysed a number of rather tiny musgravite and taaffeite samples from East Africa a few years ago for a research study (Schmetzer et al. 2007), we were stunned by three exceptional specimens which were submitted to us over the last few months for testing.

The first of these three stones was a heart-shaped musgravite of 16 ct, a size very impressive when compared to the normal range of 0.5 – 2.5 ct for this very rare collector mineral and gemstone. A second musgravite of 11 ct was submitted later in 2016 by another client, again of outstanding purity and quality. And finally, a further client submitted an exceptional taaffeite of 10 ct of purple colour (Figure 3) and very fine purity, except for a few tiny hollow channels filled with brownish orange iron hydroxide (Figure 4).

Gem-quality musgravite and taaffeite visually show a close resemblance to grey to violet spinel, but are optically anisotropic compared to isotropic spinel. They typically are very small and range in colour from purple to grey and greenish grey, with purple being the most appreciated colour. They have been found in few and mostly small specimens in Sri Lanka, Tanzania, Madagascar, and Mogok (Myanmar), which are famous for their wealth in gemstones.

Taaffeite, ideally $BeMg_3Al_8O_{16}$, is a very rare collector mineral named after Mr Richard Taaffe, who by chance discovered the first specimen in 1945 in a jewellery shop in Dublin (Ireland). Due to its visual appearance, the specimen was offered to him as a spinel and was described as a new mineral species only after his lucky discovery. Musgravite, ideally $BeMg_2Al_6O_{12}$, was first discovered in 1967 in rocks of the Musgrave Range (hence its name) in central Australia.

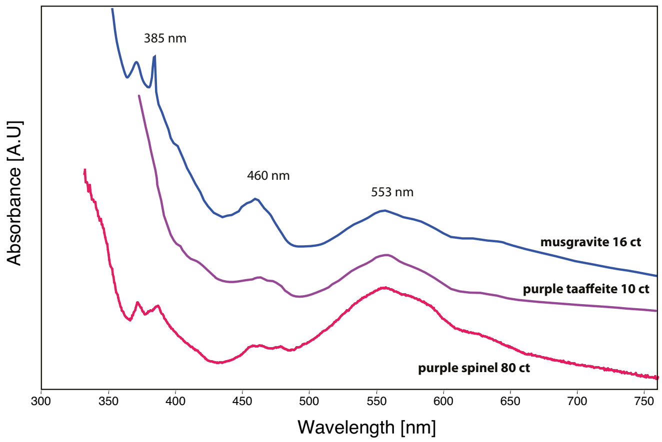
△ **Figure 3:** Musgravite and taaffeite of exceptional size and quality, which was analysed at SSEF during the past few months. Photo: SSEF



△ **Figure 4:** Hollow tubes near the girdle of the purple taaffeite (10 ct), filled with orange-brown iron hydroxide deposition. Photo: 45x magnification, M.S. Krzemnicki, SSEF

Taaffeite and musgravite are closely related in chemistry and structure and can only be separated using sophisticated structural analysis, such as Raman spectroscopy. Although renamed to magnesiotaaffeite-2N'2S (taaffeite) and magnesiotaaffeite-6N'3S (musgravite) by the International Mineralogical Association (IMA) due to their structural polytypism, the original names taaffeite and musgravite are still commonly used in the gem trade and evoke appreciation by collectors worldwide.

Interestingly, the (light) purple taaffeite showed an absorption spectrum mainly dominated by Fe-bands and no chromium band centred at 562 nm (Schmetzer at al. 2000). As such, the absorption spectrum looked similar to (slightly purplish) grey musgravite and purplish grey spinel (Figure 5). The photoluminescence spectrum (using a 514 nm laser excitation) of the same sample revealed only tiny Cr luminescence bands (doublet at 684.6 nm & 685.7 nm) and no chromium concentration in the chemical EDXRF analysis. Based on these results, we can conclude that the purple colour in our studied sample is mainly due to iron and not linked to the presence of chromium.



△ **Figure 5:** Comparison of UV-Vis absorption spectra of purple spinel, purple taaffeite (10 ct) and musgravite (16 ct), all dominated by iron related absorption bands. Spectra: SSEF

Star Spessartine from East Africa

Spessartine, the manganese end member of the garnet group is characterised by a vivid orange colour, which makes them very attractive gemstones known also as Mandarin garnet in the trade. In terms of a rare specimen, we recently had the pleasure of analysing a spessartine garnet originating from East Africa that was characterised by a distinct six-rayed star effect. Asterism in garnets has been known and documented since decades (see Schmetzer et al. 2002 and references therein). However, all available literature so far describes asterism in dark purplish brown almandine to purplish red pyrope, making this star spessartine an interesting sample.

The studied sample is a cabochon of 27 ct, displaying an even and well centred six-rayed star (Figure 6). EDXRF analysis confirmed its identity as a spessartine garnet, very much dominated by manganese on the dodecahedral {X3} structure with some magnesium and only low iron concentration. A detailed microscopic and Raman microspectrometric study revealed a dense and complex pattern of aggregated

◁ **Figure 6**: Star spessartine (27 ct) showing a distinct six-rayed star across the cabochon. Photo: L. Phan, SSEF

△ **Figure 7:** The star effect in this spessartine is mainly due to a complex pattern of intersecting oriented rutile needles accompanied by flat void platelets and partly encrusted with tiny colourless feldspar grains.. Photo: Magnification 50x, M.S. Krzemnicki, SSEF

clusters (Figure 7) consisting of intersecting oriented rutile needles accompanied by flat void platelets, partly encrusted with tiny colourless feldspar grains. Raman microspectrometric analyses confirmed the needles to be rutile, encrusted with tiny feldspar grains. The star effect visible in this specimen is mainly due to the rutile needles, possibly aligned along [110] crystallographic directions, which form, when viewed perpendicular to the octahedral face [111] three sets of needles intersecting at 60° to each other (Schmetzer et al. 2002), and thus a beautiful and regular six-rayed star after having been cut appropriately as a cabochon.

Excellent example of imperial topaz

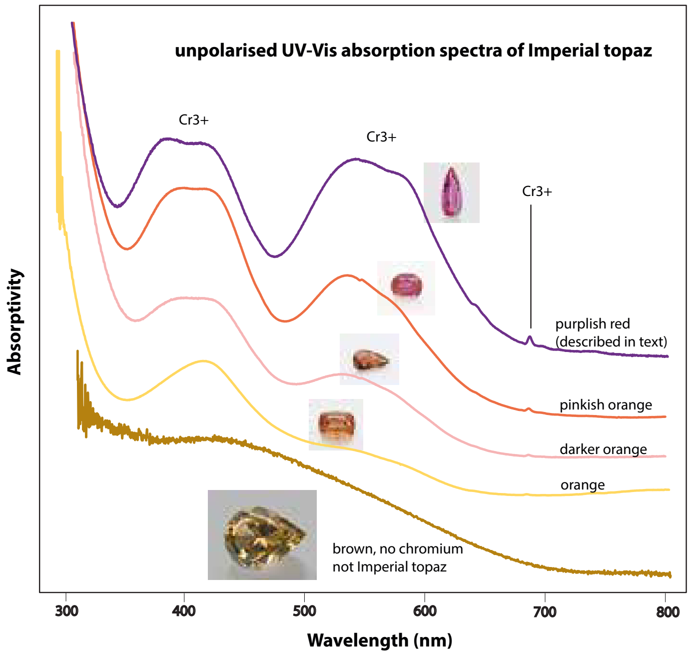
Topaz is found in many colours, with the pinkish to orange colours being the most sought after and highly priced varieties. Especially topaz in this colour range from Ouro Preto in Minas Gerais (Brazil) has a high reputation and is often named 'imperial topaz' in the trade. Although there is no harmonised criteria for this trade term - but inline with most literature sources - we consider topaz of pink to orange colour with distinct chromium absorption bands (and thus reddish fluorescence reaction under longwave ultraviolet illumination) as 'imperial topaz' and mention this trade term in the comments section of our SSEF reports.

The pear-shaped topaz of 32 ct specimen described in the following is less a matter of scientific research or curiosity, but more an example of pure beauty, which we had the pleasure of analysing at SSEF. Its analysed properties are consistent with those of topaz from the classical mining sites near Ouro Preto in Brazil. The described topaz is characterised by a saturated purplish red colour accentuated by attractive vivid orange red hues at the base and tip of the pear shape, thus perfectly illustrating the influence of the cutting style on the colour appearance of this topaz (Figure 8). Its colour is due to distinct amounts of chromium (0.17 wt% Cr_2O_3) in combination with so-called structural colour centres responsible for the orange red hues (Figure 9). A heat treatment can be excluded, as such heating would result in a deactivation of those colour centres and thus a shift of colour to pure purplish red.

Colourful tourmalines

When it comes to tourmaline, the chemical element copper is kind of the 'magic' ingredient in terms of colour and finally market appreciation. In the past few months, we have had the chance to analyse two very specific tourmalines especially in regards to their copper concentration.

◁ **Figure 8:** Imperial topaz of 32 ct showing an attractive saturated purplish red colour, accentuated by orange red reflections at the base and tip of the pear. Photo: SSEF

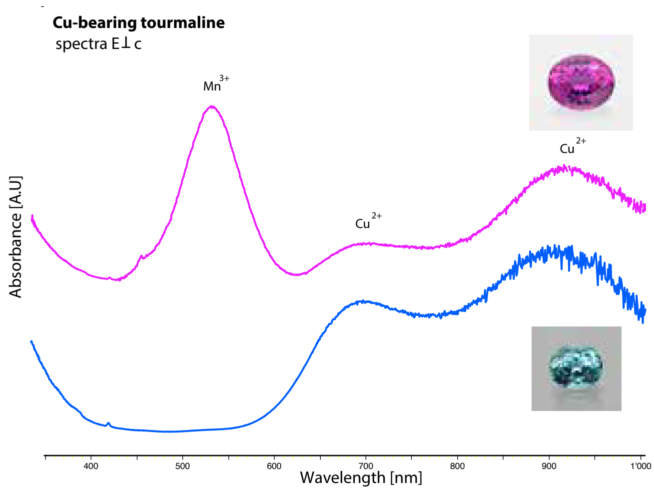


△ **Figure 9:** UV-Vis absorption spectra of imperial topaz of orange to pink and purplish red colour, all revealing chromium absorption bands at various intensities, compared to the absorption spectrum of a chromium-free brown topaz, coloured by colour centres which cause a continuous increase of absorption towards the UV. Only orange to pink topaz showing such chromium absorption bands are given the additional trade name 'imperial topaz' in the comments section of our SSEF reports. Figure: M.S. Krzemnicki, SSEF

△ **Figure 10:** Copper bearing tourmaline (40 ct) of vivid purple colour from Mozambique and tourmaline of weak greenish blue saturation containing only small traces of copper, and thus not considered Paraiba tourmaline by SSEF. Photo: SSEF

The first specimen was an impressive copper-bearing tourmaline (40 ct) of vibrant and vivid purple colour and exceptional purity (Figure 10) originating from Mozambique (East Africa). The chemical analysis revealed minor amounts of copper and manganese as main contributors for the attractive colour of this gem, and iron below detection limits. The UV-Vis absorption spectrum showed two characteristic broad Cu-bands in the near infrared (about 700 and 920 nm) and a high and dominant Mn^{3+} absorption band (centred at 530 nm), which in fact is responsible for the vibrant colour due to the marked transmission windows on the sides of this absorption band (Figure 11). It is a well known fact that this manganese absorption band quickly disappears when heating such tourmalines at rather moderate temperatures (Abduriyim et al. 2006; Milisenda et al. 2006; Laurs et al. 2008). Consequently, the colour of such Cu-bearing purple tourmalines will shift into a highly desired and more expensive vibrant blue colour through the heating process. This explains why most copper-bearing purple tourmalines are heated. In this case, it was a stunning experience to see how beautiful the purple colour of such copper-bearing tourmalines can be if spared from heat treatment.

The second tourmaline was of even larger size (60 ct), showing a subtle greenish blue colour of weak saturation (Figure 11). The chemical analyses of this tourmaline revealed a very low concentration of



△ **Figure 11:** Absorption spectrum of the described purple tourmaline (40 ct), showing very distinct Cu and Mn absorption bands which are responsible for its vivid colour, compared to the spectrum of a heated blue copper-bearing (Paraiba) tourmaline from Mozambique. The absorption band at 530 nm related to Mn^{3+} disappears during heat treatment, resulting in a shift of colour from purple (before heating) to blue (after heating). Figure: M.S. Krzemnicki, SSEF

copper (0.04 wt% CuO), together with manganese and iron as minor constituents. Even though of very low concentration, the copper was still partially responsible for the colour, in combination with iron (Fe^{2+} - Fe^{3+} intervalence charge transfer absorption band at about 720 nm). Although containing traces of copper, this tourmaline of weak colour saturation is not considered a Paraiba tourmaline, based on our SSEF standards and LMHC guidelines (LMHC Information Sheet 6 on Paraiba tourmaline), but still an extraordinary gemstone of subtle and appealing colour. ✶ **Dr. M. S. Krzemnicki, SSEF**

COMMENTS FOR UNDETECTABLE TREATMENTS

Whether we like it or not, it is a scientific fact that not all treatments applied to gemstones are detectable. This is especially the case for gemstones, which owe their colour to irradiation, either natural irradiation within the host-rock or artificial irradiation during a treatment process. Such gemstones where treatment detection is not always or even rarely possible include certain colour varieties of tourmaline, namely Paraiba tourmaline, topaz, zircon, aquamarine and other beryl varieties, and not to forget certain fancy coloured green diamonds.

After reconsideration of our wording standards, and following the recommendation of the international LMHC committee (see Information Sheet No. 8: http://www.lmhc-gemology.org/pdfs/IS8_23092010.pdf), we decided in the beginning of 2016 to add in such cases a standard comment on our reports:

The colour of 'gemstone' may be improved or changed by a treatment.

It is currently not possible to determine if the described 'gemstone' has been treated or not.

The colour is however considered stable.

△ **Figure 1**: This Paraiba tourmaline from Brazil of excellent colour ('neon blue') shows spectroscopic features which clearly indicate that it is unheated. Unfortunately, not all Paraiba tourmalines contain such evident features. In cases where it is not detectable if the Paraiba tourmaline was heated or not, the new standard comment (see text) will be added on our reports. Photo: SSEF

The last statement is only added in case the colour is considered stable under normal conditions, such as Paraiba tourmaline, aquamarine and other gemstones.

Although this ambiguity is not always easy to explain, we are convinced that it is our duty to fully inform the client about the limitations of analytical gemmology. We can reassure our clients that we are actively involved in scientific research to expand our knowledge about treatment detection with the aim to be able to positively identify any applied gem treatments in future. ✶

◁ **Figure 2**: It is not always possible to determine if a morganite has been treated or not. Photo: SSEF

◁ **Figure 3**: Rubellite tourmaline such as this may be treated to modify their colour. Detecting such treatments can be challenging. Photo: SSEF

NEUTRON AND X-RAY TOMOGRAPHY OF EMERALDS

Since two years, the SSEF has been working with the Laboratory for Neutron Scattering and Imaging at the Paul Scherrer Institute (PSI) using their ICON beamline (cold neutron imaging) at the SINQ spallation source. The aim of these research projects in collaboration with Dr. Lehmann and Dr. Mannes is to analyse the internal structure of pearls and gems with neutron radiography, darkfield imaging, and tomography.

In 2016, we focused our research at PSI on the 3D-visualisation of inclusions and fissure fillings in a number of selected emeralds, notably from Colombia, Brazil, and Sandawana in Zimbabwe (Figure 1). These results were then compared to high-resolution X-ray microtomographical analyses of the same specimens.

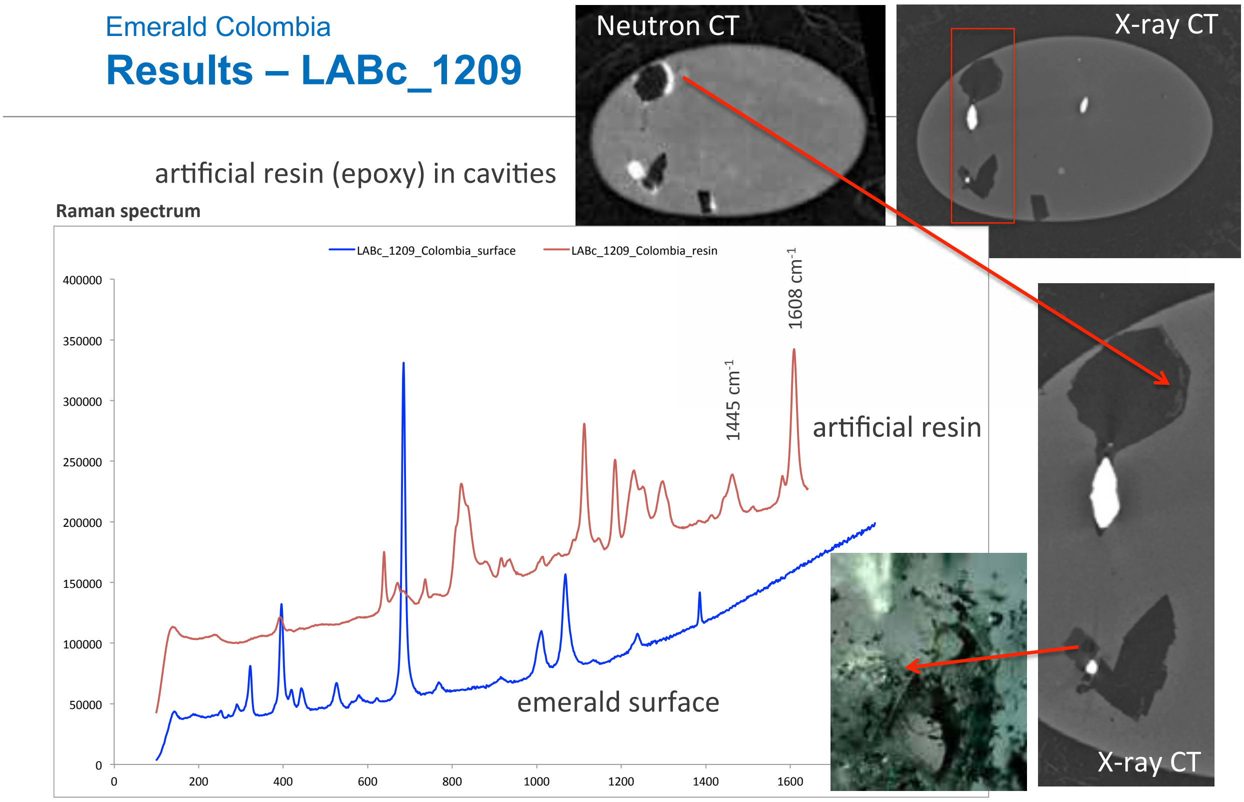
What makes neutron imaging interesting, is that neutron interaction with atoms is not influenced by their electron cloud. This is very much in contrast to X-rays, for which the interaction (attenuation) is closely correlated to the number of electrons (and atomic number Z) of an element. Therefore, neutrons can penetrate deeply into matter which is strongly absorbing for X-rays. As such, neutron imaging may reveal important complementary information of the internal structure of materials. This is especially the case in hydrogenous materials (i.e. containing hydrogen, e.g. organics), which induce strong neutron scattering reactions.

The preliminary results of our study revealed that it is possible to visualise the complex pattern of inclusions and fissures filled with organic fillers, e.g. oil or resin in emeralds with reasonable resolution and get a 3D insight into their orientations.

Although a thorough microscopic observation assisted with FTIR and microraman spectroscopy is in most cases sufficient for the characterisation of internal features and the identification of fissure filling, this new approach will open up further possibilities in gemstone research (Mannes et al. 2016, Krzemnicki et al. 2016), such as the characterisation of 'Trapiche' growth patterns in gemstones, jadeite textures and impregnation, and pearl identification.

✶ **Dr. M. S. Krzemnicki, SSEF**

◁ **Figure 1: Analysed sample from Sandawana (Zimbabwe) from the SSEF reference collection (H.A. Hänni subcollection) with densely aggregated fibrous amphibole inclusions. Photo: M.S. Krzemnicki, SSEF**



△ **Figure 2: Comparison of neutron and X-ray CT imaging revealing open cavities in a Colombian emerald partially filled with artificial resin (identified by Raman microspectrometry). Figure: M.S. Krzemnicki, SSEF**

THE HISTORIC 'SLEEPING LION PEARL', A NATURAL BLISTER AND NOT A PEARL

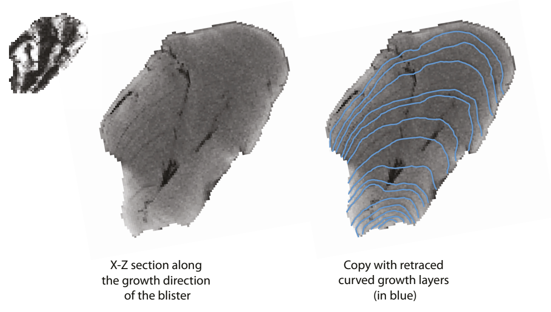
Recently, the Swiss Gemmological Institute SSEF had the opportunity to investigate an impressive natural nacreous formation with documented provenance dating back to the late 18th century, named the 'Sleeping Lion Pearl' due to its baroque shape that is reminiscent of a lion (Figure 1).

△ **Figure 1:** **The historic 'Sleeping Lion Pearl' – in fact a natural blister, seen from the side and somehow reminiscent of a sleeping lion. Photo: V. Lanzafame, SSEF**

Originating from a freshwater mollusc, this historic 'pearl' was first documented 1778 as being sold in Amsterdam (Netherlands). Just a year later, it was sold again in St. Petersburg (Russia), and from there went through several hands throughout Europe until it was finally sold in Italy to the Dutch goldsmith Lodewijk Willem van Kooten who brought it back to Amsterdam in 1868, where it stayed in private hands until present. A detailed description of the historical provenance of the 'Sleeping Lion Pearl' can be found in Zwaan & Dommisse (2009) and Zwaan et al. 2014 (both in the Journal of Gemmology).

Having read about the 'Sleeping Lion Pearl' in gemmological literature, we were very impressed by the size and weight of the item when we received it earlier this year (approximately 69.90 x 44.00 x 38.00 mm and weighing 593.25 ct). The colour was light cream with subtle rosé, purple and green overtones. Such overtones are due to an iridescence effect on the nacreous surface and greatly contribute to its beauty.

What followed was a meticulous study, which revealed that the nacreous formation historically known as the 'Sleeping Lion Pearl' in fact represents a **natural blister** that formed in a freshwater mollusc, and is neither a pearl nor a blister pearl. This conclusion is based on careful visual observations, and mainly relies on a detailed three dimensional analysis of its internal structures using X-ray microtomography (Yxlon Cougar at SSEF). It showed no onion-like spherical ring structures in the nacreous formation typical for pearls or blister pearls, but only curved layers of nacre (Figure 2) deposited on each other in a 'mushroom'-like structure indicating proliferating (pathological) nacre accumulation on the shell forming this enormous blister.



△ **Figure 2:** **A microtomographical section (XZ orientation) along the growth direction of the described blister reveals no onion-like ring structures (as expected for a pearl or blister pearl), but only curved and accumulated (stacked) layers of nacre, characteristic for a natural blister formation. Figure: M.S. Krzemnicki & J. Braun, SSEF**

How to define blister, blister pearl and pearl?

In principle, any mollusc producing a hard shell and living in freshwater or marine waters may form a calcareous concretion by a process known as biomineralisation. In historic times, all these natural products were commonly called 'pearls', although since then three main categories have been defined (see also CIBJO Pearl Book), based on differences in their formation and appearance.

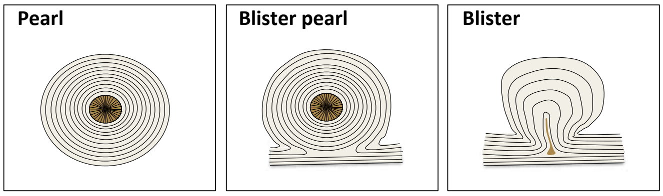
Natural pearls form in a **pearl sac** within the mantle tissue of the mollusc due to an irritation of the mantle tissue and are made of ± spherical rings of calcium carbonate (e.g. nacre). They **are not attached to the shell.**

Natural blister pearls start to form as a pearl, but eventually their pearl sac disintegrates partially, with the result that the mantle tissue on the inner side of the shell starts to cover this pearl with nacreous layers. It is now **attached to the shell** and called a **blister pearl**. A cross section through a blister pearl will reveal concentric (spherical) rings of calcium carbonate (e.g. nacre) in the inner part, wrapped by subsequently formed layers of calcium carbonate (e.g. nacre) which are continuous with those of the inner side of the shell (see CIBJO pearl book) and thus attach the blister pearl to its shell. To be used in jewellery, blister pearls have to be cut from the shell. As a consequence, they are commonly polished/worked at the base. In some cases, a blister pearl may also fall off the shell quite easily when the shell is harvested.

Natural blisters are nacreous formations **bulging on the inner surface of a shell**. They form spontaneously due to an irritation of the mantle tissue of a mollusc or by the intrusion of foreign bodies on the inside of a shell. A cross section through a nacreous blister will reveal curved and more or less half-domed layers of nacre inside, optionally with hollow cavities but no onion-like ring structures as in pearls or blister pearls.

Blisters are part of the shell and as such always have to be cut from the shell. As a consequence, they are polished/worked at the base. Blisters are more common than pearls or blister pearls. If they are large, they are generally understood as being the product of proliferating growth of the mantle tissue, thus they commonly reveal a baroque shape with deep surface indentations and rippled outline and then often very much dominate the shell in which they form (see Figure 3).

Based on our findings, we conclude that this exceptional item - historically known as the 'Sleeping Lion Pearl' – is in fact the result of such proliferating nacre accumulation on the shell and thus represents a natural blister. It has to be noted that at the time it was named, any nacreous formation from within a shell was called a pearl, as the modern concept to distinguish pearls from blister pearls and blisters was not yet known. ✶ **Dr. M. S. Krzemnicki, SSEF**



△ **Figure 3: Schematic drawing of the internal structure (cross section) of a pearl, a blister pearl and a natural blister. Both, pearl and blister pearl are characterised by onion-like spherical rings of calcium carbonate (shown here in brown: calcite, in grey: nacre), whereas a blister is formed by bulging layers only, with or without a hollow cavity. Figure: M.S. Krzemnicki, SSEF**

△ **Figure 4: Example of a large proliferating (pathological) blister formation on the inner side of a freshwater shell. Photo: H.A. Hänni, SSEF**

PURPLE MOZAMBIQUE GARNET

In early 2016, attractive bright purple garnets arrived at SSEF (Figure 1) in Bangkok, Basel and Hong Kong. Based on client information, they are from a new mine, Padagaga in the Chimoio area in Mozambique, which was discovered recently (Schwarz, 2016).

After routine gemmological testing, the chemistry of these garnets fits with rhodolite, within the solid solution series pyrope ($Mg_3Al_2Si_3O_{12}$) – almandine ($Fe_3Al_2Si_3O_{12}$). EDXRF analysis shows main chemical composition is around: Fe_2O_3 27%, MgO 17%, Al_2O_3 19% and SiO_2 36% with minor amounts of CaO and MnO. Comparing this to published data (Lind, 2015, Schwarz, 2016 and Sangsawong 2016), the UV-Vis spectra (Figure 2) shows Fe^{2+} absorptions that dominate (around 500-700 nm, especially the ones from 500-600 nm) together with a mixture of Mn^{2+} (ca. 410 nm), while the contribution of V^{3+} + Cr^{3+} (420 to 430 nm and 515-530 nm) is relatively low.

Since this new material only recently appeared on the market, further studies are required to entirely understand the gemmological differences between this and stones from traditional localities like Tanzania and Malawi. We look forward to seeing many more such charming purple rhodolite garnets in the SSEF. ✶ **Dr. W. Zhou, SSEF**

△ **Figure 1: Three purple rhodolite garnets tested by SSEF at the beginning of 2016, ranging in weight from 7 to 13 carats. Photo: SSEF**

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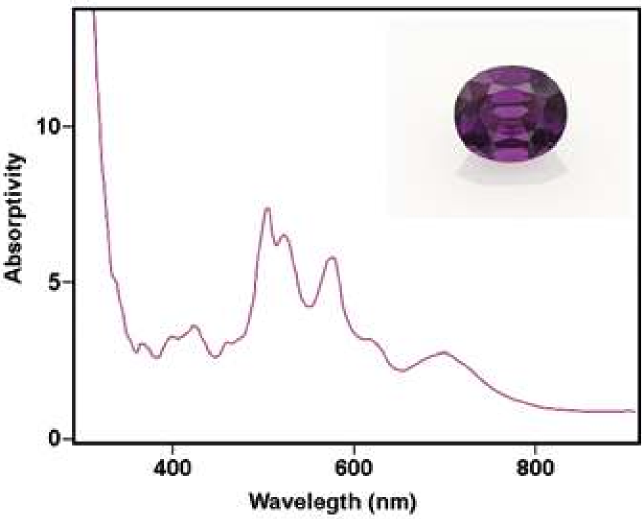


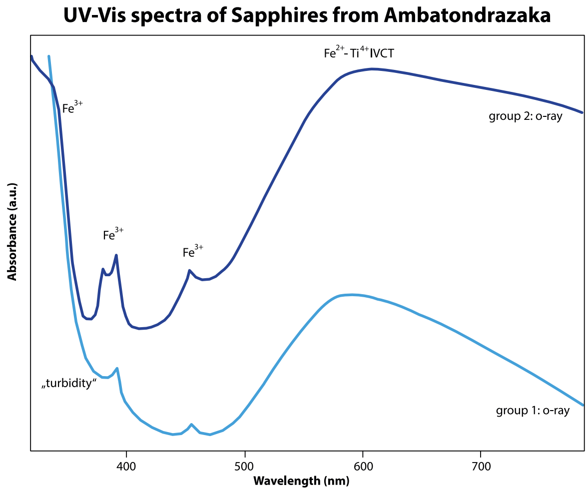
NEW SAPPHIRES FROM AMBATONDRAZAKA, MADAGASCAR

Madagascar, an island of many gem treasures, saw in recent months another 'sapphire rush' after the discovery of a new gem deposit about 35 km east of the small town of Ambatondrazaka (Perkins & Pardieu 2017). With about 50'000 artisanal miners working the gravels of this secondary alluvial deposit, this new site has so far reportedly produced quite an impressive amount of mainly blue sapphires, including some large rough stones up to 30 g of exceptional quality, and additionally some pinkish orange sapphires. These stones of fine quality are currently arriving in the gem market in larger quantities, part of them having been treated (heated) to improve their colour and clarity.

SSEF recently analysed a number of sapphires from this new source ranging in size from 1.3 ct to 34 ct (Figure 1). Most of the analysed sapphires were rather pure with a medium strong to strong blue colour, sometimes with a slight greyish to greenish tint. Absorption spectroscopy showed that these sapphires can be separated into two categories, both of metamorphic origin, with one group of sapphires exhibiting only small absorption features by Fe^{3+} and somehow reminiscent of sapphires from Sri Lanka and Kashmir with slight turbidity. The other group consists of mostly dark saturated sapphires with rather distinct Fe^{3+} related absorption features, also known from Burmese sapphires (Figure 2).

△ **Figure 1**: Part of the sapphires from the new deposit near Ambatondrazaka in Madagascar that were recently studied by SSEF. Photo: SSEF

Many of the studied specimens exhibit a slight to marked milkyness due to submicroscopic fine particles in zones and banding, but only occasionally have small rutile needles. They also show characteristics found in gem-quality sapphires from other metamorphic deposits in Madagascar (e.g. Andranondambo and Ilakaka), such as very distinct and narrow growth zoning. This zoning may also result in a 'chaotic' three-dimensional pattern, occasionally showing brownish greyish interference colours (Figure 3) when viewed in transmission. A few samples also contained hollow channels that were somehow etched (Figure 4). Furthermore, we found colourless prismatic zircon



△ **Figure 2**: Absorption spectra (o-ray) of sapphires from Ambatondrazaka studied at SSEF. Spectra recorded with the portable UV-Vis spectrometer developed by SSEF (SSEF Facette 15, 2008).

inclusions surrounded by marked tension fissures, a black flake (presumably graphite) with small comet-like dust trails, and fine dust-lines with tiny intersections. Although the visual appearance of some of these sapphires may show similarities with sapphires from Kashmir, they miss the highly characteristic inclusions of Kashmir sapphires. The very dark sapphires rich in Fe^{3+} were often very pure, in contrast to Burmese sapphires that often contain numerous small and characteristic inclusions. ✶ **Dr. M.S. Krzemnicki, SSEF**

△ **Figure 3**: Dense 'chaotic' pattern of growth lines with greyish interference. Photo: M.S. Krzemnicki, SSEF

△ **Figure 4**: Fine corroded hollow channels at the girdle of this sapphire from Ambatondrazaka. Photo: M.S. Krzemnicki, SSEF

RUBIES WITH OIL IN FISSURES

The matter is actually very simple. Any gem material with fissures is prone to be treated with a fissure filler to reduce the visibility of fissures (Figure 1). Astonishingly, the understanding of this basic concept has only penetrated the trade when it comes to emeralds. For all other gemstones, many gemstone dealers react totally surprised when explained that the gemstone they submitted contains a filler substance in fissures. Although such treatments are known since historic times (Nassau 1994), and should be of no mystery to anybody in the field of gemstones, it is unfortunately a fact that fissure filled gemstones still today are often not properly disclosed at the point of sale.

△ **Figure 1**: The choice is yours! Oil fillers displayed in a shop in Chantaburi, Thailand. Photo: M.S. Krzemnicki, SSEF

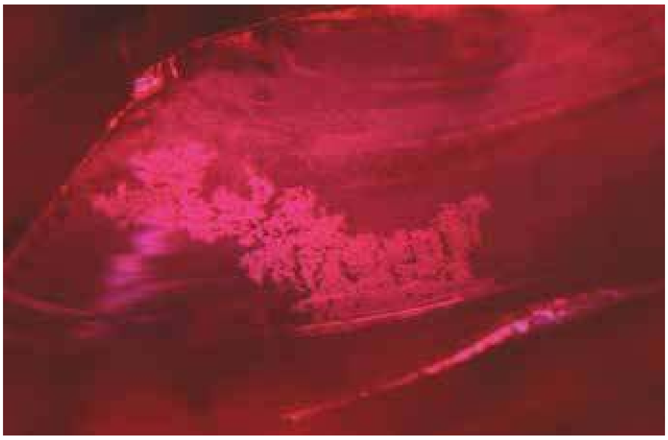
Over the past few years, the SSEF has repeatedly seen gemstones (apart from emeralds) which contained fissures filled with oil or other fillers. These include rubies, sapphires, spinels, tourmalines, garnets and even rarities such as pezzottaite (see article in this Facette). We could however not observe a notable increase of such clarity enhanced gems in recent years.

△ **Figure 2**: A typical case of ruby beads containing fissures which are filled with colourless oil. Photo: H.A. Hänni, SSEF

By far the most cases were encountered with rubies, especially unheated ones from Myanmar (Burma), which occasionally were found to show fissures mainly filled with oil or wax (Figure 2). Some purplish to pinkish rubies contained orange oil in fissures, with the aim of shifting the colour of the ruby into a more vibrant red (Figure 3).

△ **Figure 3**: The orange oil in this ruby fissure shifts the apparent colour of the stone. Photo: M.S. Krzemnicki & V. Lanzafame, SSEF

Identification of fissure fillers in rubies or other gemstones is based on the same analytical methods as for emeralds: a combination of FTIR, Raman microspectrometry, UV luminescence and meticulous microscopic observations (Figure 4). In some cases, the oil in these fissures may even spill out of the fissures when exposed to a hot needle (Hughes 2016) or even a hot light source (of the microscope).



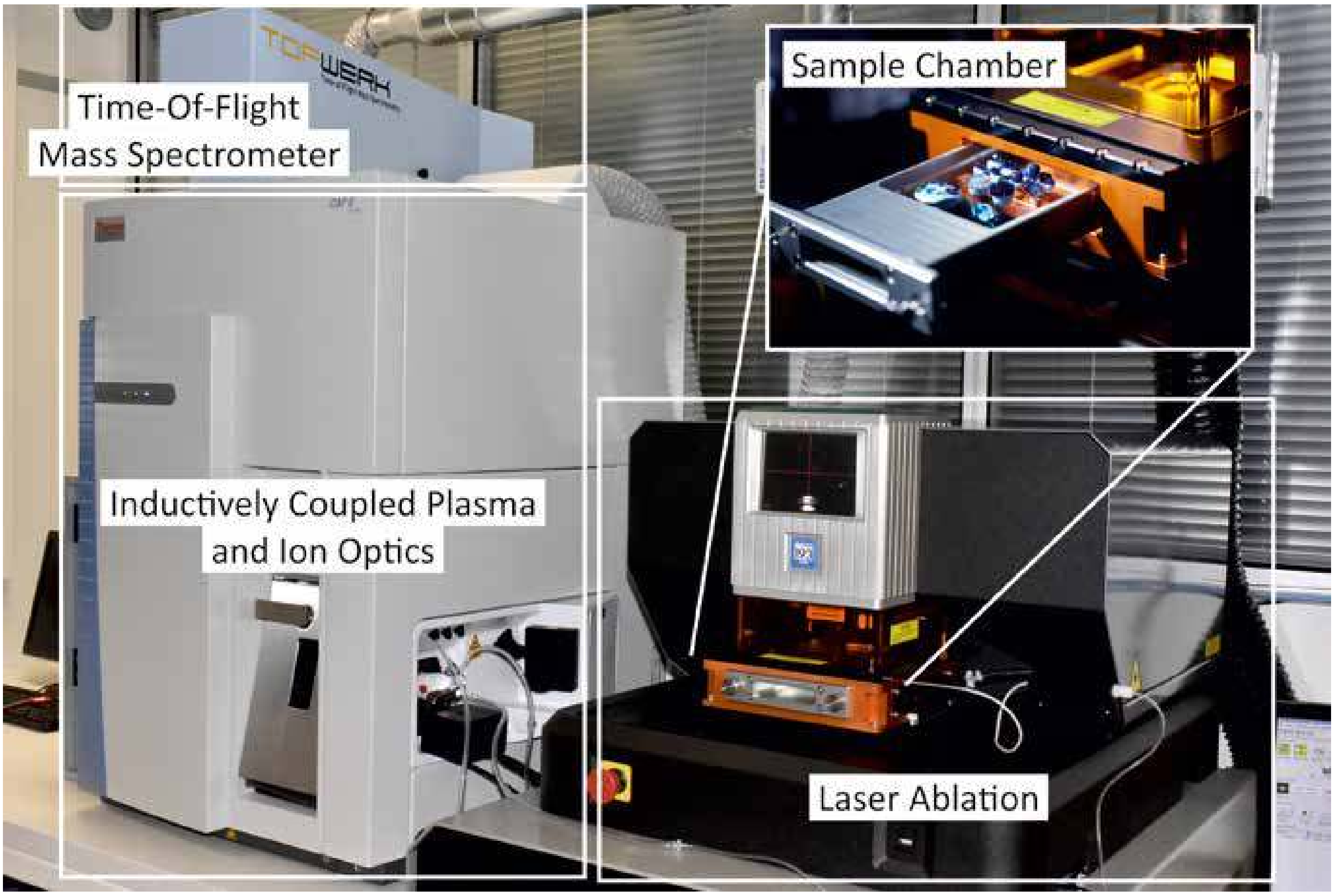
△ **Figure 4**: Fine dendritic structures of air bubbles penetrating back into the oil filled fissure in this ruby. Photo: H.A. Hänni, SSEF

Based on our experience and gemmological literature on the history of treatments, the concept of filling fissures with a (colourless or even coloured) substance is quite old and may even be found in antique jewellery. Therefore we consider oil or wax in fissures a traditional treatment, which however still requires full disclosure. As such, the SSEF identifies and quantifies fissure filling in any gemstone, and comments about such clarity modification are reported using very similar wording and classification than for emeralds. ✶ **Dr. M.S. Krzemnicki, SSEF**

SSEF FIRST LAB TO INTRODUCE GEMTOF

The world of gemstones is changing rapidly. Not only does the number of sources of new mining sites increase, but also new treatment methods as well as advanced synthetic techniques are being developed. With the increasing complexities and challenges, the characterisation of a gemstone has developed from measuring some basic physical properties (e.g. density, refractive index) to structural and chemical properties applying sophisticated and advanced analytical techniques (e.g. FTIR, Raman, X-ray techniques and Neutron techniques). As one of the most important chemical properties, the elemental composition of a gemstone reflects its unique geological environment and conditions at the time of formation. Therefore, a comprehensive understanding of the elemental composition provides a characteristic chemical fingerprint to tackle different challenges such as origin determination, treatment detection and synthetic stone separation. To strengthen the capability of elemental analysis, the Swiss Gemmological Institute SSEF recently acquired and implemented one of the latest scientific instruments – GemTOF – for quantification of major, minor, trace and even ultra-trace elements in gemstones.

GemTOF is a next-generation elemental analytical instrument, which is based on Laser Ablation-Inductively Coupled Plasma-Time Of Flight-Mass Spectrometry (LA-ICP-TOF-MS), a recent advent in the family of LA-ICP-MS. As pictured in Figure 1, GemTOF consists of three main parts. A Laser Ablation (LA) unit houses precious gemstones and the high energy ultra-violet laser ablates only a tiny spot on the surface of the gemstone girdle. The ablated material forms fine particles, which are transported into the ICP unit through a gas line. Depending on the gemstone variety that is tested, laser spot size varies, but is generally comparable to or less than the diameter of a human hair. The laser spot depth is much smaller than the diameter. Therefore, the introduced laser spots on the gemstone girdle are hardly visible to the naked eye and the beauty of the gemstone will not be influenced after GemTOF analysis. An ICP unit together with ion optics sits to the left which transforms these fine particles into elemental ions using a plasma source with a temperature close to that of the surface of the sun, under which condition almost all fine particles are atomised, ionised and sampled into mass spectrometer. Subsequently, the TOF-MS, on top of ICP unit, simultaneously separates these ions into different elemental and isotopic species. A detailed description and investigation of LA-ICP-TOF-MS performance can be found in research articles in Journal of Gemmology (Wang et al, JoG, 2016), or InColor magazine (Wang et al, InColor, 2016) and Gold'Or (Krzemnicki et al, 2016, in German).



△ **Figure 1:** GemTOF setup installed at SSEF is in operation since autumn 2016. Photo: SSEF

Advantages of GemTOF

As currently the only such instrument installed among gemmological laboratories, GemTOF is similar to but also distinctively different to LA-ICP-Quadrupole-MS, which has been applied for more than a decade in gemstone testing (Guillong et al, 2001; Abduriyim et al, 2006; Nyfeler; 2016). Fundamentally, they vary in the way how people think and conduct the experiment. Before each gemstone is ablated, the operator of LA-ICP-Q-MS must determine a predefined list of elements/isotopes, hence any elemental information not included in this predefined list will be missed. In case other elements are needed, the gemstone has to be re-ablated which requires time and further ablation. In a more logical and natural experimental protocol, GemTOF first acquires almost all elements in the periodic table from Lithium (Li) to Uranium (U), and then determines which elements are interesting for analysis, thanks to the full mass spectrum acquisition capability of TOF mass spectrometer. In case of a missing element, GemTOF raw data can be re-evaluated and no re-ablation is needed. A few other elements not measured by GemTOF are not suitable for analysis by LA-ICP-MS in general.

GemTOF is also one of the fastest data acquisition instruments on the LA-ICP-MS market and is hundreds of times faster than LA-ICP-Q-MS. A Q-MS instrument sequentially scans interested elements in the pre-defined list. Depending on the signal integration time on each element (0.01 – 0.02 second) and the total number of elements (a few dozen), the complete scan of the whole list may take half a second. On the contrary, GemTOF saves 1'000 full mass spectra per second, which is limited only by the data transfer rates from TOF-MS to PC and has the potential to increase to 33'000 full spectra per second. Together with its full mass spectrum capability, this high speed performance of GemTOF is particularly valuable when analyzing short time-duration signals, for example those resulting from ablation of a minute inclusion or a tiny area/pixel when conducting chemical imaging.

Despite its advantages, GemTOF is not as sensitive compared to other LA-ICP-MS instruments. One of the reasons is that it has to balance the merits of light to heavy elements at the same time. A low sensitivity directly influences the lowest concentration of elements that can be detected. However, owing to a low detector background noise, GemTOF is able to measure as low as parts per billion (ppb) concentrations of heavy elements and low parts per million (ppm) for light elements using routine measurement parameters. Such a performance, although not comparable to other state-of-the-art LA-ICP-MS instruments, satisfies most of the daily and research work in gemmology. In case an increased sensitivity is needed on a particular mass range, instrument parameters can be further optimised.

Another challenge of GemTOF measurement is the complicated data reduction and evaluation procedure. With the entire elemental mass spectrum, comes the complex mixture of mass peaks of interest and interferences resulting from different elements and molecules. A detailed study is currently underway to understand every component in the full mass spectrum and further improve the reliability of results.

Applications of GemTOF
Origin determination of gemstones

The most popular application of LA-ICP-MS in gemmology is to characterise gemstones from different origins based on their elemental compositions. LA-ICP-MS often provides valuable chemical evidence in addition to traditional gemmological analyses for origin determination.

Importantly, the geochemical and growth condition differences during formation may embed clues in the presence of other elements, in the differences of elemental concentration and in the variation of isotopic patterns of a certain element. GemTOF is capable of collecting almost all elemental information in the periodic table routinely and covers a wide concentration of major, trace and even ultra-trace elements. It is hence critical in showing a unique and comprehensive chemical fingerprint of a gemstone providing more confident origin information through multivariate statistical analysis.

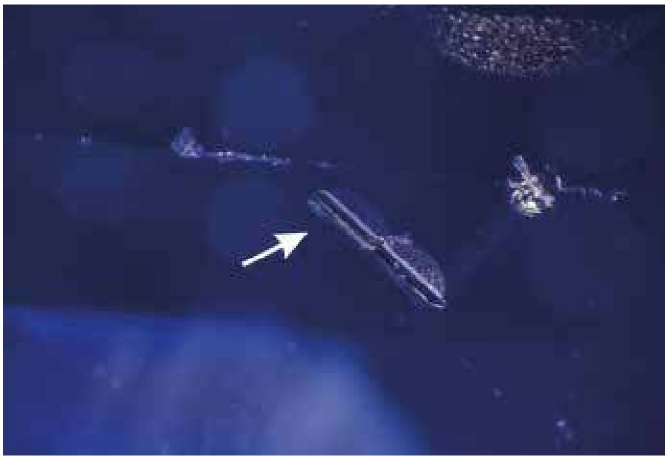
△ **Figure 2:** Six blue sapphires (weighing approximately 2–36 ct) are shown on an historical map of the famous gem locality of Mogok, Myanmar. Quantitative chemical data can be helpful for determining the geographic origin of sapphires. Map from Gordon (1888); Photo by L. Cartier and J. Xaysongkham, SSEF

Diffusion treatments and coating detection on gemstones

GemTOF behaves in a proactive way. Since it measures almost all elemental compositions in real-time, any unexpected signal intensity is readily spotted during the analysis, which reveals new and undisclosed chemical treatments such as chemical diffusion or coatings. In a case like when beryllium diffusion treated corundum hit the market in the early 2000s, GemTOF should be able to alert in the first place and avoid confusion in the trade (and gemmological laboratories). This is very much in contrast to LA-ICP-Quadrupole-MS which analyses only a predefined list of elements, and thus misses out information on elements not included.

Age dating and inclusion analysis of gemstones

Some elements include naturally occurring radioactive isotopes. Radioactive isotopes decay in a constant rate from parent isotopes to daughter isotopes and can last millions or billions of years. Hence, by measuring the isotopic ratios of the pair, the age of the geological sample can be obtained. Zircon is popular for geological age dating. Determining the formation time of zircon indirectly estimates the age of its host mineral (e.g. sapphire, Figure 3). Full mass spectrum obtained by GemTOF intrinsically contains isotopic patterns of elements. In addition, because all isotopes are measured simultaneously and with a high acquisition speed, GemTOF results in high precision in isotopic ratio determination especially when measuring short-duration signals, such as those resulting from tiny zircon inclusion in sapphire (Figure 3). It is also worth to mention that at the same time as geological age is being determined, GemTOF also acquires the elemental composition of the zircon inclusion. Besides zircons, others inclusions, for example those with unknown composition, would be ideal for GemTOF analysis. Analysis of inclusions can be especially useful, since such tiny 'time-capsules' preserve hints of geochemical environments and growth conditions when the host mineral was formed.



△ **Figure 3:** Zircon inclusion (white arrow) in sapphire can provide indirect estimation about the geological age of the gemstone. Photo: M.S. Krzemnicki, SSEF

Conclusion and outlook

GemTOF, currently running at the Swiss Gemmological Institute SSEF, is a state-of-the-art instrument dedicated to trace element analysis of gemstones. This newly added analytical strength is capable of measuring almost all elements in the periodic table simultaneously, which improves confidence on origin determination and detection of unrevealed diffusion treatments and coatings. Additionally, ultra-fast data acquisition allows us to study various inclusions in host gemstones. Investigations on inclusions are expected to provide insight to more detailed formation histories. Mainly, GemTOF is contributing to routine gemstone analysis at SSEF. In parallel, we are carrying out research such as inclusion studies, isotopic analysis, chemical imaging and statistical analysis, both internally and externally with collaborative partners.

Special Notice

Although GemTOF analysis is hardly visible to the naked eye, by agreeing to SSEF's Terms & Conditions (on backside of new SSEF Order Form and on SSEF website), clients agree to GemTOF testing. These state that **unless explicitly excluded by the client in the order, GemTOF can be carried out on submitted Gemstone(s) without further note.** Pearls and diamonds are not routinely tested by GemTOF.

Acknowledgement

We acknowledge TOFWERK AG, ESI Europe and ThermoFisher Scientific for general support. The Swiss Association of Gemstone Dealers (ASNP) is appreciated for their generous donation. ✶ **Dr. H.A.O. Wang**

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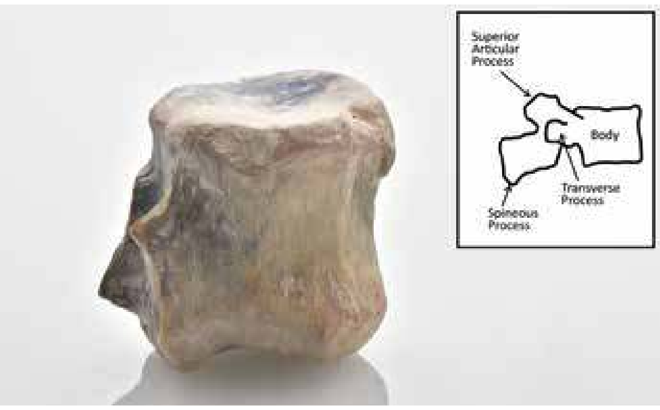
STUDY OF AN OPALISED DINOSAUR VERTEBRA

Recently, the Swiss Gemmological Institute SSEF received an exceptional opalised dinosaur vertebra for study. This specimen was reportedly from Lightning Ridge (New South Wales in Australia) – a world famous source of dark opals and opalised plant and animal fossils - and was already photographed by Elizabeth Warren for her book Black Opal Fossils in 1999 (see page 88). The studied dinosaur vertebra is impressive in size (approx. 85 x 79 x 50 mm) and weight (501 grams), and consists of brownish greyish common opal (also known as 'potch') with no play-of-colour, partially interlayered with precious opal showing distinct and vivid blue and green play-of-colour. Its shape is dominated by a massive vertebra body with broken lobes, which are assumed to represent relics of the articular and traverse processes of the vertebra (see Figure 1). Based on the shape and size of the item, we assume that the studied specimen represents a distal member of the caudal vertebrae of a large dinosaur (Figure 2), such as the theropods, a saurischian suborder, which comprises the largest land-living carnivores such as the *Tyrannosaurus rex* (see also Warren 1999).

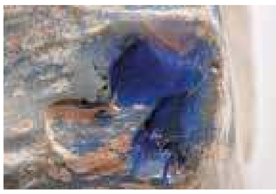


△ **Figure 1: Opalised dinosaur vertebra investigated recently at SSEF in vertical position and inset showing a generalized side-view of a vertebra. Photo: Wei Zhou, SSEF**

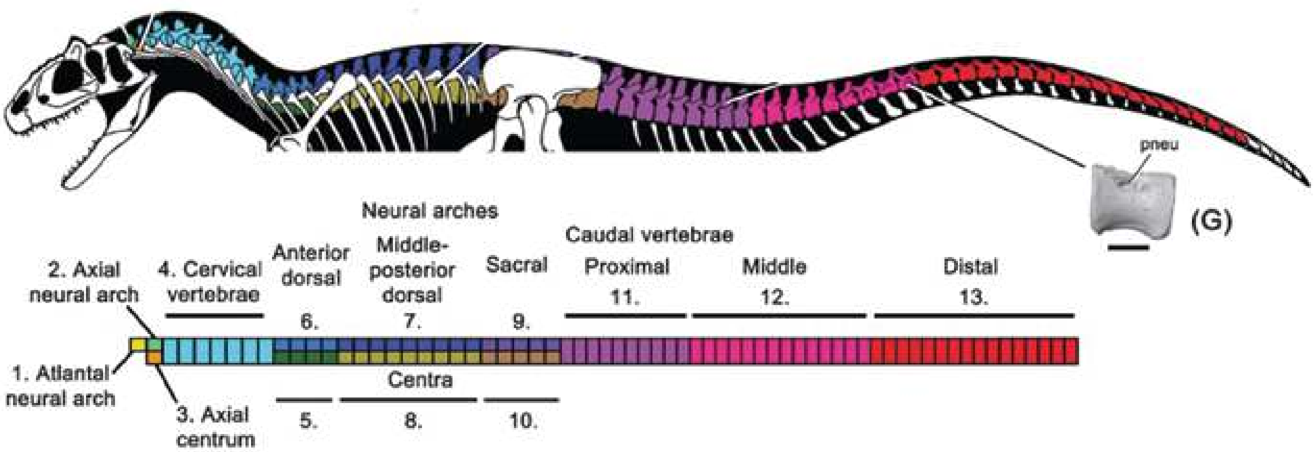
A close-up study revealed lateral linear striations at the side and a complex texture of opalised pores (probably representing the original *Substantia spongiosa*) at the base and top of the vertebra (Figure 3). The opalised part is best seen in a chipped off part at the side of the vertebra. It is characterised by a vivid play-of-colour, dominated by blue (Figure 4). Under ultraviolet illumination, the opalised vertebra shows patchy bluish-white fluorescence, followed by a distinct phosphorescence after switching off the UV lamp, an effect well known for opals from Australia (Gaillou et al., 2008). Due to the sample size and unpolished rough surface, only a qualitative chemical X-ray fluorescence analysis (ED-XRF) could be performed. Apart from silicon, the main constituent of opal ($SiO_2 \times nH_2O$), it revealed minor amounts of calcium, potassium, iron, titanium, and traces of manganese, nickel, copper, and zinc, well known for opals from Australia (Gaillou et al., 2008).

To conclude, this opalised dinosaur vertebra is a very interesting specimen for study, as it provides not only an insight into the process of silicification of an ancient fossil into a gemmy opal with beautiful play-of-colour, but mostly also as it is a remaining trace of the fauna of Northeastern Australia in the Mesozoic. ✶ **Dr. M.S. Krzemnicki, Dr. W. Zhou, SSEF**

◁ **Figure 3: Side view of the opalised vertebra with linear and porous structures (probably *Substantia spongiosa*). Photo: Wei Zhou, SSEF**



◁ **Figure 4: Close-up showing the strong play-of-colour of the precious opal on a chipped-off part of the vertebra. Photo: Wei Zhou, SSEF.**



△ **Figure 2: Skeleton reconstruction of dinosaur (allosaurus) with different vertebral sections. Based on the visual resemblance with vertebral piece (G), the studied opalised vertebra is assumed to represent a distal member of the caudal vertebrae of a large dinosaur. Figure adapted from Benson et al. 2011.**

FAKE TRIDACNA PEARLS

Fake pearls are beads (of whatever shape) which have been cut entirely from shell material. A perfect source for the production of such fake pearls is the Tridacna clam, amongst the largest living bivalve mollusc with a massive and thick shell of up to 110 cm diameter, mainly living along shallow coastal waters in the Indo-Pacific region (Rosewater, 1965). Due to recent the media coverage of an exceptional 'pearl' from a giant clam (Tridacna) and its intriguing provenance (August 2016, http://www.bbc.co.uk/news/world-asia-37167179), the SSEF is currently confronted with numerous requests to analyse similar 'giant pearls'.

In summer 2016, we then had the opportunity to analyse a series of five items, which were submitted to us as natural Tridacna pearls originating from Palawan, island in the east of the Philippines, including one specimen of 6.8 kg (!) and 27 cm maximum length (see Figure 1).

A detailed study of these items quickly revealed that they were fake pearls, cut from the shell of Tridacna clams to imitate genuine pearls. The most striking feature of all these fake pearls was a distinct and partly complex layering, which was however not related to the shape of the items, but merely represents the seasonal growth layers of the Tridacna clam shell from which these fake pearl had been cut. Furthermore, the surface showed distinct polishing marks in random orientations, indicating rushed production of these fake pearls. In some of the studied samples we could also observe weak flame structures similar to those known from queen conch shells and pearls (*Strombus gigas*) due to densely interwoven bundles of aragonite fibres (Hänni 2010).

Although natural pearls or blister pearls have been occasionally reported in Tridacna shells, they have rarely been of great interest due to their often rather dull whitish appearance and their commonly baroque shape. However, we would like to remind readers that not all non-nacreous white natural pearls claimed to be pearls from Tridacna clams necessarily originate from Tridacninae. They may also be the beautiful product of other mollusc species and be mislabelled as Tridacna clam pearls as there is still today no method for species identification of such non-nacreous white pearls, very much in contrast to nacreous pearls which among others can be separated genetically (Meyer et al., 2013) and by spectroscopic methods.

It is not the first time that we encounter beads cut from the shell of molluscs to imitate pearls, but the described items were definitely the largest fake pearls ever analysed at SSEF.

Although often uncritically distributed by news agencies and accompanied by 'fantasy' documents and appraisals, it should be noted that Tridcana clams are among the most endangered clams and protected by CITES (2016). Any trade of pearls, shell, or even fake pearls is strictly regulated by customs and requires official documentation.

A detailed report about these fake pearls, including a comparison to fake pearls previously tested at SSEF is published in the upcoming Journal of Gemmology Vol. 35, No. 5, 2017. ✶ **Dr. M.S. Krzemnicki**

△ **Figure 1**: The five fake pearls cut from a Tridacna clam analysed for this study. The largest specimen is characterised by a bulging shape, representing the undulating wavy shape of the clam itself. All these fake pearls show distinct layering at their surface. Photo: V. Lanzafame, SSEF.

△ **Figure 2**: Close up of the layered structure encountered in all of the studied fake pearls. These layers represent seasonal growth of the clam itself from which these fake pearls were manufactured. Image width 11 mm. Photo: M.S. Krzemnicki, SSEF

EXCEPTIONAL JADEITE-JADE AT SSEF

In the past few months, the SSEF has again analysed a number of jadeite jewellery items, mostly of outstanding quality. Jadeite testing at SSEF follows a sophisticated analytical procedure, as conclusions on mineralogical identity and treatment have to be drawn. Jadeite as a gemstone is a polycrystalline rock which may contain several different mineral phases (especially in cases of lower quality). Furthermore, it belongs to a large group of pyroxenes and is only called jadeite-jade when fitting with the mineralogical criteria of the International Mineralogical Association IMA (see also LMHC Information Sheet No. 11).

Another important issue is the detection and correct disclosure of any treatment, commonly heavy impregnation by colourless fillers (e.g. artificial resin, wax or oil) and even dyeing (Figure 1), thus protecting the trade and consumers from undisclosed material.

◁ **Figure 1**: Pair of ear-pendants with impregnated and green dyed jadeite-jades, in Asia also known as type B+C jadeite-jade (or Fei Cui B+C). A close look reveals many open pores and grain boundaries at the surface of these stones, which are prone to be filled by a filler substance and thus a good first hint for possible impregnation treatment. Photo: SSEF

In the following we present a selection of jadeite-jade of exceptional quality, starting with an impressive pair of jadeite jade cabochons (Figure 2) of 26 ct and 23 ct, respectively. They are both characterised by an excellent lustre and a very homogeneous vivid green colour, combined with outstanding translucency. This translucency is due to the very fine and densely interlocked texture of jadeite grains within these two cabochons. It results in an 'inner glow' effect due to scattering and reflection of light on grain boundaries. In addition to these qualities, both cabochons showed no indication of any impregnation or other form of treatment. In the Asian market such jadeite may also be called 'jadeite-jade type A (Fei Cui type A)'.

◁ **Figure 2**: Exceptionally well-matching jadeite cabochons (23 ct and 26 ct) of excellent quality. Photo: J. Xaysongkham, SSEF

Apart from this, we tested a beautiful vivid green jadeite-jade necklace and ear pendants accentuated with saturated red rubies (Figure 3), and an impressive necklace containing seven large and beautifully matching green jadeite beads (diameter up to approx. 26.70 mm), alternating with smaller jadeite beads and flanked by two jadeite carvings and a very fine green jadeite cabochon at the clasp. Based on the provided documentation, the design of the necklace is a modern interpretation (Figure 4) of historical court necklaces in use during the Qing dynasty from 1644 until the end of the Imperial period in the early twentieth century. ✶ **Dr. M. S. Krzemnicki, SSEF**

△ **Figure 3**: Modern (ear pendants) and classical (necklace) combination of green jadeite with vivid red rubies. Photo: SSEF

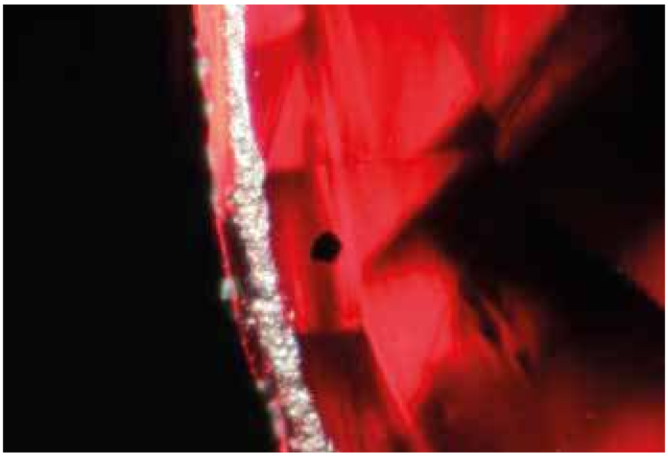
△ **Figure 4**: Necklace containing seven impressive jadeite beads in a modern interpretation of historical court necklaces in use during the Qing dynasty. Photo: SSEF

SYNTHETIC RUBY WITH ESKOLAITE INCLUSION

End of 2016, a ruby necklace containing 69 rubies in total was submitted for testing. Under the microscope, rutile needles, crystal inclusions and other natural features were found in most of the rubies, while one very pure ruby with one small dark inclusion drew gemmologists' attention (Figure 1).

△ **Figure 1:** The appearance of this synthetic ruby. Photo: SSEF

This ruby of 0.21 ct and around 4.5 mm in diameter was unset to complete further analysis. EDXRF data showed that chemically it had no gallium (Ga), iron (Fe) or vanadium (V) and was dominated by aluminium (Al) and chromium (Cr) only. The suspicion over its authenticity was very high, and the question over the 'natural' dark inclusion (Figure 2) remained. Was this inclusion an indication for a natural origin? Using Raman analysis, the inclusion was identified as being eskolaite (Cr_2O_3), a pure end member of Al_2O_3-Cr_2O_3 solid solution series and that is rarely found in the natural world.



△ **Figure 2:** A black inclusion inside a very pure 'ruby', around 0.15 mm in length. Photo: SSEF

People have been using the Verneuil flame fusion method or crystal pulling process to synthesise rubies for decades. There are two essential components required in order to synthesise ruby using these methods: extremely pure aluminum oxide (Al_2O_3) and a small amount of chromium oxide (Cr_2O_3) to give the red colour. Our hypothesis is that the uncommon eskolaite inclusion inside this synthetic ruby synthesised from the nutrient powder under a critical HTHP condition (Chatterjee, 1982) and crystallised during the ruby synthesis process.

✶ **Dr. W. Zhou, SSEF**

REFERENCE

Chatterjee, D. N., Leistner, H., Terhart, L., Abraham, K., and Klaska, R., (1982) Thermodynamic mixing properties of corundum-eskolaite, α-(Al, Cr+3)$_2$O$_3$, crystalline solution at high temperatures and pressures, American Mineralogist, 67, 725-735.

THE FIFTY SHADES OF GOLDEN PEARLS: NEW TREATMENTS

Cultured pearls with a saturated yellow to golden colour are highly appreciated in the trade. Most commonly they are produced as beaded cultured pearls in the gold-lipped South Sea pearl oyster (*Pinctada maxima*), e.g. in the Philippines by Jewelmer and a few other pearl farms in Southeast Asia, as a result of careful breeding and shell selection.

It is therefore not astonishing to find quite a number of colour treatments with the aim to enhance or modify the colour of pearls into such desired yellow to golden shades. In the last few months we analysed pearls treated by three reportedly new treatments, ranging from rather simple dyeing using an unknown dye, to more sophisticated treatments (Figure 1).

All treated pearls were detected using a combination of Raman microspectroscopy, Photoluminescence spectra and UV-Vis-NIR reflectance spectroscopy, apart from a careful microscopic observation, which revealed in one case of beaded cultured pearls from Pinctada maxima (submitted from the Japanese market) distinct brownish rim around the drill-hole (Figure 2), classic feature of pearls dyed after drilling. The 'pistachio' colour treated pearls we analysed at SSEF were beaded cultured pearls from *Pinctada margaritifera* (a.k.a. black South Sea pearls). They showed no suspicious colour concentrations similar to the treated pearls described by Zhou et al. (2016), but quite a stunning greenish golden 'pistachio' colour. Finally, we acquired a beaded freshwater cultured pearl (so-called Edison Pearls) of treated yellow colour, which was properly disclosed at the point of sale. ✶ **Dr. M. S. Krzemnicki, SSEF**

△ **Figure 1:** Three treated cultured pearl samples examined by SSEF. Photo: SSEF

△ **Figure 2:** Beaded cultured pearl from *Pinctada maxima* with distinct brownish rim around the drill-hole. Photo: SSEF

RESEARCH ON GOLDEN PEARLS

The South Sea pearl oyster *Pinctada maxima* is known to produce white, cream and golden pearls. Such pearls are cultured mainly in Australia, Burma (Myanmar), Indonesia and the Philippines. Interestingly, 2016 marked the 60th anniversary of the first harvest of South Sea cultured pearls at the Kuri Bay farm (Australia), established by Tokuichi Kuribayashi of Nippo Pearls in 1954 (Müller, 1997). In the past few decades, South Sea cultured pearls have become some of the most desired and expensive cultured pearls in the market.

At present, golden South Sea cultured pearls are harvested mainly in Burma, the Philippines and Indonesia. Pearl farmers have targeted traits and oysters that can enable them to focus on specific nacre colours and thus pearl colours. In February 2016 Dr. Laurent Cartier had the opportunity of visiting Jewelmer pearl farms near Palawan Island in the Philippines and observing the different culturing techniques required to harvest golden South Sea pearls. The Jewelmer company was co-founded in 1979 by Jacques Branellec and Manuel Cojuangco with the aim of producing high-end golden South Sea cultured pearls.

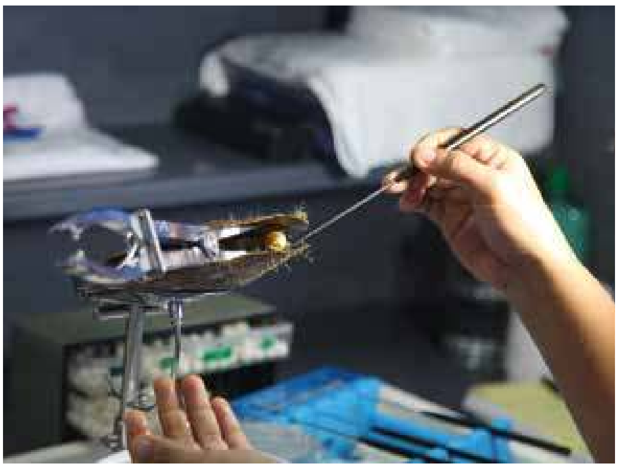
Untreated high-quality golden South Sea cultured pearls from the *Pinctada maxima* oyster continue to be rare and highly sought after on the international market. This complexity (both ecologically and technically) associated with cultivating these pearls is a limiting factor in offering the market larger quantities of such high quality cultured pearls. Treatments to attain and imitate such pearl colours and qualities will continue to exist, and SSEF is carrying out research on such treatments. As such, it is also very important to visit production sites and collect reliable samples for research. So it is important that both gemmological research and correct disclosure (see CIBJO Pearl Book) are followed. Another aspect of pearls that SSEF has been very active in is DNA fingerprinting of pearls, such as those from *Pinctada maxima.* In order to continue to brand and market South Sea cultured pearls from *Pinctada maxima* as such it is important to be able to distinguish these at a gemmological level, between them and pearls of similar colour from other species. The appreciation of golden South Sea cultured pearls will continue to rise as this relatively new resource in the jewellery industry gains wider attention and embodies a golden future.

For more information also see Cartier & Krzemnicki (2016)

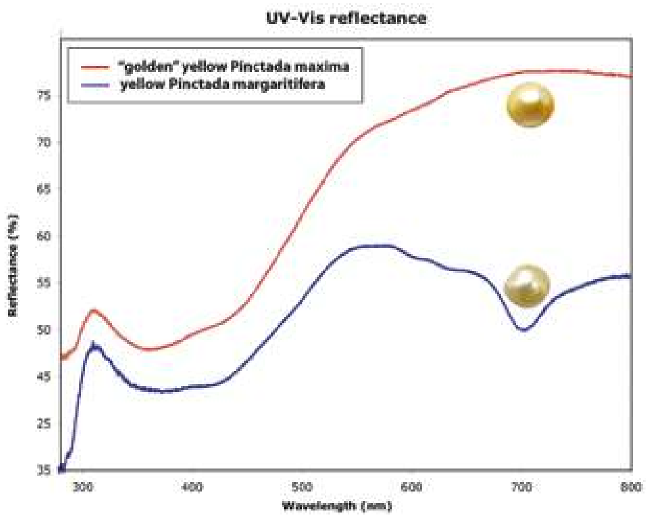
✶ **Dr. L.E. Cartier, SSEF**

◁ **Figure 1: Untreated golden South Sea pearls from the Jewelmer pearl farms in Palawan (Philippines). Photo: L.E. Cartier, SSEF**

△ **Figure 2: Fig. 3 Approaching the Terramar Four pearl farm. The mangrove and coral-rich environment is a good source of nutrients for pearl oysters. Photo: L.E. Cartier, SSEF**



△ **Figure 3: Fig. 8 Harvesting a golden South Sea cultured pearl after several years of work. Photo: L.E. Cartier, SSEF**



△ **Figure 4: UV-Vis reflectometry spectra of a yellow *Pinctada margaritifera* cultured pearl and a golden yellow *Pinctada maxima* cultured pearl. Spectrum: SSEF**

WHY IS A DIAMOND OF TYPE IIB BLUE TO GREYISH BLUE?

When a chemically pure diamond is only made of carbon atoms, it is classified as type IIa, and when crystal defaults are absent, it is colourless.

In a type IIb diamond some boron atoms substitute with diamond's carbon atoms and a very weak concentration of boron - in the order of a few ppb (a few boron atoms per billion carbon atoms) is sufficient to create a bluish grey, greyish blue to blue colour. This is the case of some very famous diamonds such as the Hope diamond or the Wittelsbach-Graff diamond.

Comparing the absorption spectra of type IIa and type IIb diamonds greatly helps to better understand why a diamond of type IIb is blue to greyish blue.

Looking at the absorption spectrum of a type IIa diamond between 10'000 nm to 200 nm (Figure 1), one notes that this diamond does not absorb any light between 2'500 nm and 230 nm. At these wavelengths the type IIa diamond is perfectly transparent and this includes the visible range wavelengths, between 800 nm and 400 nm that human eyes are sensitive to- hence its perfect colourlessness (D colour grade). Interestingly, in the mid-infrared (between 2'000 nm and 7'000 nm) the pure type IIa diamond absorbs a lot of light; these absorptions are due to chemical bonding of carbon atoms between themselves, hence the name of this region: diamond's intrinsic absorption region.

Now, looking at the absorption spectrum of the greyish blue type IIb diamond (Figure 2), one notes that this last absorption region is greatly different than that of the chemically pure type IIa diamond. The difference is due to the presence of boron atoms which greatly modifies the diamond's intrinsic absorption region. For instance, the type IIa diamond at 2'500 nm does not absorb any light (the absorption coefficient at this wavelength is nil; and this is also the case of most other diamonds of type I) but at the same wavelength, the diamond of type IIb absorbs a lot; up to an absorption coefficient of 5. Looking further at smaller wavelengths we see that this type IIb absorption regularly decreases towards the visible light region and still absorbs in the red part (800 to 600 nm) of the visible range.

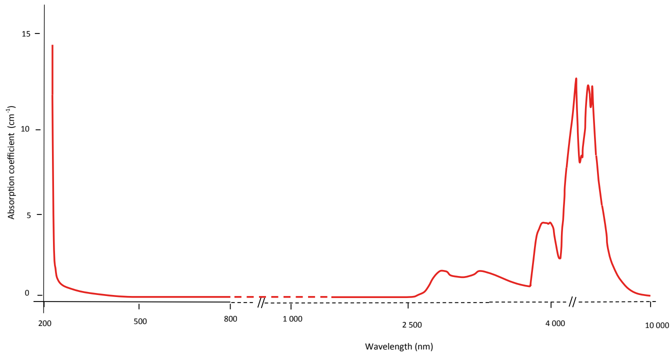
The diamond's absorptions in the visible range give a direct explanation of the diamond's colour. One should remember that:

(1) a human being's eyesight is more sensitive to yellow

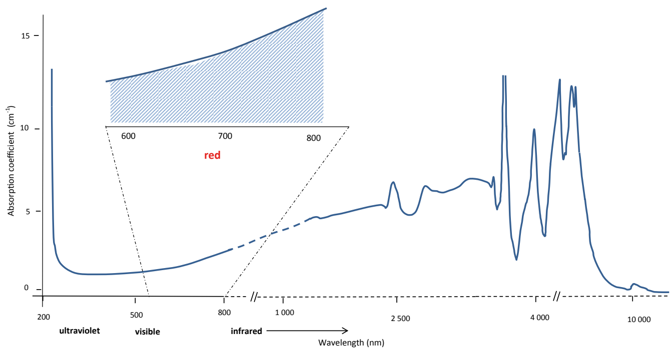
(2) any transparent material illuminated with white light and absorbing a specific colour will appear in the complementary colour.

For instance, a diamond absorbing wavelengths in the blue range will be seen yellow; a diamond absorbing wavelengths in the red range will be seen blue and a diamond absorbing all wavelengths of the visible range will be seen grey to black.

Having a last look at the type IIb absorption spectrum, we now understand that this type IIb diamond is greyish blue for two reasons: 1) the tail of absorptions due to the presence of boron absorbs in the whole visible range (between 2 and 3 in absorption coefficient), hence its greyish hue and 2) absorbs more in the red than in other ranges of the visible spectrum, hence its bluish hue. The combination of the two (see the striped zone in the inset of Figure 2) results in the typical greyish blue colour of such a type IIb diamond.
✶ **J.-P. Chalain, SSEF**



△ **Figure 1:** Absorption spectrum of a type IIa diamond. Spectrum: SSEF



△ **Figure 2:** Absorption spectrum of a type IIb diamond. Spectrum: SSEF

△ **Figure 3:** Blue diamond tested at SSEF. Photo: SSEF

UMBA RUBY OF 30 CT WITH ZIRCON SPECTRUM

Detection of heat treatment in corundum mainly relies on a combination of meticulous microscopic observation and analyses by Raman microspectrometry and FTIR spectroscopy. Especially in the case of low-temperature heating of rubies and pink sapphires, the analysis of the shape of Raman peaks of zircon inclusions has proven to be an important criterion for heat treatment detection, even when microscopic features are not very conclusive. This is due to the fact that the very broad Raman peaks of metamict zircon inclusions are distinctly transformed into sharp Raman peaks during a heating process (Zhang et al. 2000, Nasdala et al. 2001, Wang et al. 2006, Krzemnicki 2010, and SSEF Facette 2010, No. 17, page 12).

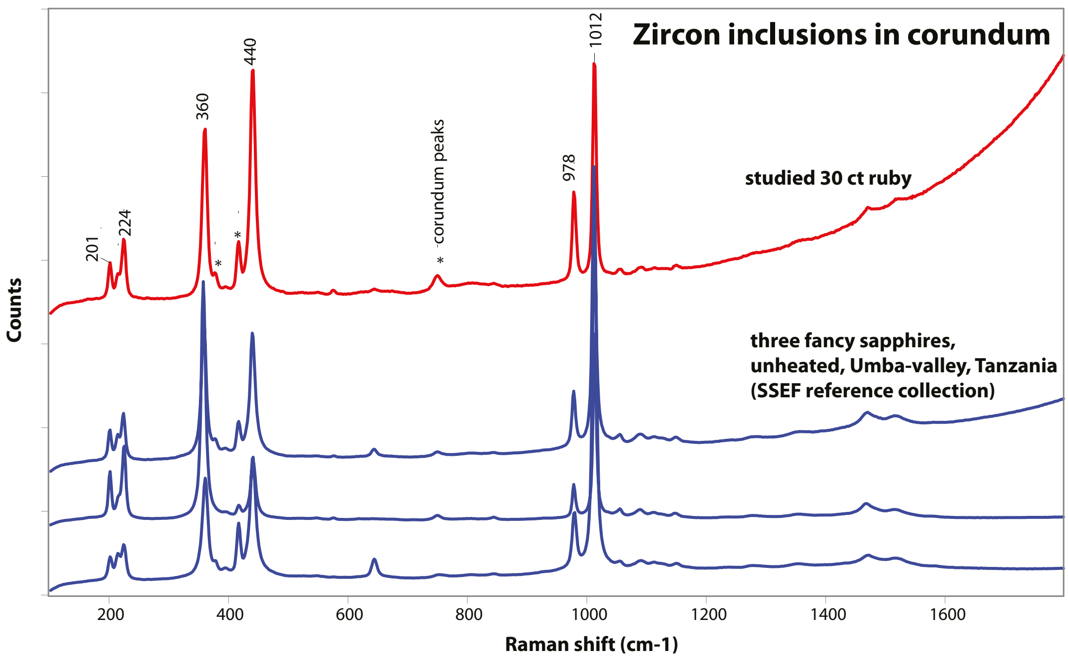
Although a very valuable method especially for corundum from Madagascar (Ilakaka) or southern Tanzania (e.g. Tunduru) which contain highly metamict zircon inclusions, it is important to understand that the peak shape of zircons in Raman spectra may vary considerably depending on the geological setting and formation conditions of a corundum crystal, and thus also when comparing corundum with zircon inclusions from different geographic origins (see also SSEF Facette 2012, No. 19, page 14).

Recently, the SSEF received a ruby of 30 ct for testing (Figure 1), which exhibited a slightly orange red colour and an exceptional purity. Based on the comparison of the observed microscopic features and analytical properties with our SSEF reference collection (including the H.A. Hänni subcollection) and gemmological literature, this gemstone was highly consistent with rubies from the Umba valley in northern Tanzania, known in the trade as a source of corundum (mainly fancy sapphires) since decades (Zwaan 1974; Gunawardene 1984; Hänni 1986 and 1987). The host rock of these corundum crystals mostly found in alluvial deposits in the Umba valley is a pegmatite intruding a serpentinite (Solesbury 1967).

The microscopic observations did not reveal any transformations of the present inclusions (e.g. frosted surface of zircons or enlarged expansion fissures). The Raman spectra taken on several zircon inclusions within this ruby, were however characterised by sharp vibrational peaks (but no luminescence peaks), which might be interpreted as an indication of a heat treatment. But when comparing the Raman spectra of the zircon inclusions in this exceptional ruby with unheated reference material from the Umba valley (from H.A. Hänni subcollection), we consistently found very sharp and marked Raman peaks of the zircon inclusions in both.

This not only added a layer of confidence in the origin determination of the client stone, but also shows that an interpretation of a heating process based on Raman spectra of zircon inclusions has to be carried out carefully, to avoid misinterpretation of analytical results in terms of possible treatment detection. ✶ **Dr. M. S. Krzemnicki, SSEF**

◁ **Figure 1:** Exceptional ruby of 30 ct tested recently at SSEF. Photo: V. Lanzafame, SSEF



△ **Figure 2:** Comparison of Raman spectra of zircon inclusions from the studied 30 ct ruby with unheated reference material from Umba valley (Tanzania). The sharp Raman peaks of the zircon inclusions in corundum from this deposit are not an indication of a heat treatment, but rather reflect their formation conditions. Figure: M.S. Krzemnicki, SSEF

HEATED PINK SAPPHIRE IN ANTIQUE JEWELLERY

Recently, the SSEF received an antique necklace, containing 23 rubies and pink sapphires together with a fine selection of old cut diamonds. The design of the necklace indicated a presumable age of this antique jewellery of mid 19th century, which was also confirmed by the information about the provenance of this jewellery item provided by the client. A careful microscopic observation of the setting showed no signs of any unmounting and resetting of stones, nor did the rather strong wear marks on the gemstones suggest any reworking or gemstone replacements.

Interestingly, one pink sapphire in this necklace showed distinct atoll-structures (Figure 2) due to molten inclusions, clearly indicating that this stone of Sri Lankan origin had been heated. In contrast to this, all other rubies and pink sapphires (majority Mogok-type Burmese stones) showed no indications of heating. The finding was quite a (bad) surprise for the client who did not expect any heated stone in this antique necklace.

Heating of gemstones is often and wrongly thought to be a rather modern treatment, although in fact it has already been known and described by Pliny the Elder in Roman times. Especially in Sri Lanka (Ceylon), artisanal heating of gemstones (at rather low temperatures) to improve their colour and/or clarity is known and practised since many centuries, although certainly not as often as today.

This heated pink sapphire - although of lower value due to our findings - proves actually to be an important reminder to the trade and gemmologists alike that heated corundum may even be encountered in antique jewellery. ✶

△ **Figure 1:** Antique necklace containing 22 unheated rubies and pink sapphires and one heated pink sapphire. Photo: V. Lanzafame, SSEF

△ **Figure 2:** Small but distinct atoll-structures of molten inclusions in the heated pink sapphire of the described antique necklace. Photo: M.S. Krzemnicki, SSEF

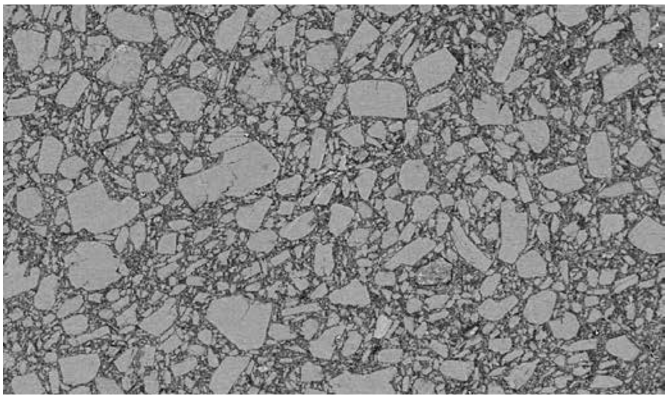
GIBBSITE UNVEILED AS A CORAL IMITATION

Sometimes we read about re-constructed gemstones, for example amber chips molten together or assembled with epoxy resin. But already with re-constructed turquoise one may question whether any turquoise is even present. Most material from the trade that we have so far encountered was in fact barium sulfate or bayerite α-$Al(OH)_3$. We have reported in the past, for example on Galatea carved Tahitian cultured pearls with turquoise imitation beads made of $BaSO_4$.

During a recent trip to Idar Oberstein small heart shaped tablets were given to us for analysis. It was expected that they would to be re-constructed coral. The material has a light orangy colour, and small irregular particles could be seen under the microscope. If it were re-constructed coral it should contain milled coral material. The testing was thus first an EDXRF analysis to prove the presence of calcium (Ca) as coral is a calcium carbonate. Interestingly, the material showed no Ca, but aluminium (Al). A second test used the micro Raman for an identification of the components by their crystallographic nature. The result was gibbsite γ-$AlOH_3$. This result is in good agreement with the chemical test. We then brought the samples to the Basel Centre for Microscopy in order to see the surface with 250x magnification. Using the EDX-option again, Al was again proved to be the main component, and Ca to be absent.

Regarding the cause of colour we can exclude coral again, given that polyenes did not show up in the Raman spectrum. The correct identification of this material is thus orange Gibbsite, as a coral imitation.
✶ **Prof. H.A. Hänni**

△ **Figure 1**: Imitation or reconstructed coral? Photo: SSEF



△ **Figure 2:** Sample viewed under high magnification. Photo: ZMB

HIGHLIGHTS AT AUCTION WITH SSEF REPORTS

As in previous years, the following paragraphs are dedicated to reviewing an eclectic selection of the most prestigious or beautiful gemstones, pearls and jewellery at auction in 2016, which were analysed at SSEF and accompanied by an SSEF report. This year's selection has a special twist, as it presents not only items sold by Christie's and Sotheby's, but also jewels sold by auction houses such as Bonhams, Phillips, Poly auction, Tiancheng International and Woolley & Wallis.

Magnificent rubies

As every year, we will start our 'tour d'horizon' with magnificent rubies, which were sold at auction in 2016 and that again achieved the highest prices for coloured gemstones.

In April 2016, the **Jubilee ruby** of 15.99 ct, set in a ring by Verdura, was sold at Christie's in New York for US$ 14.1 million (SSEF report 80019). Apart from its remarkable size, this ruby was characterised by an attractive vivid colour and a fine purity, a combination rarely encountered in Burmese rubies of this size. Among exceptional rubies at auction - all of Burmese origin – we also have to mention two ruby rings which were sold at the November sales in Geneva: a **ruby of 8.37 ct** (SSEF report 62508) set in a Cartier ring at Sotheby's for US$ 4.3 million and a ring with a **ruby of 7.08 ct** (SSEF report 87463) sold at Christie's for US$ 2.3 million.



△ From left to right: Jubilee ruby of 15.99 ct, set in a ring by Verdura. Photo: Christie's - 8.37 ct ruby set in Cartier ring. Photo: SSEF - 7.08 ct ruby in ring Photo: SSEF

The sales in Hong Kong offered again several exceptional rubies throughout the year 2016. In May, Christies sold a pair of highly **matching rubies (5.05 and 5.01 ct)** (SSEF report 84465) for US$ 1.4 million and an exceptional **ruby bracelet** of 29 graduated cushion-shaped rubies (SSEF report 85032) for US$ 3.5 million.

◁ Beautiful pair of rubies (5.05 and 5.01ct) sold by Christie's. Photo: SSEF

△ Exceptional bracelet with 29 highly matching rubies. Photo: SSEF

In June, Tiancheng International sold a **ruby** in a ring (SSEF report 81683) by Tiffany's & Co. for US$ 1.3 million, and later in December an impressive **necklace set with 24 heart-shaped rubies** of a total weight of 48.08 ct (SSEF report 87618) sold for US$ 2.3 million. In the autumn of 2016, Bonhams Hong Kong sold an octagonal **ruby** of 4.00 ct (SSEF report 83795) for US$720'000, Phillips a pair of highly **matching Burmese rubies** in ear pendants (SSEF report 87984) for US$ 600'000, and Sotheby's a **ruby of 5.07 ct** (SSEF report 86030) set in a ring for US$ 1.95 million.

△ Impressive necklace set with 24 heart-shaped rubies. Photo: SSEF

Two of the most exceptional ruby rings were offered at Christie's Hong Kong end of 2016, a **cushion-shaped ruby of 5.01 ct** (SSEF 62208) of excellent purity and red colour, set in ring in a modern and artistic flower design, which sold for US$ 1.87 million, and the **'Ratnaraj' ruby**, an exceptional 10.05 ct gem of colour (SSEF report 88472), which sold for US$ 10 million, thus setting a very positive mark at the very end of the auction year.


△ 10.05 ct 'Ratnaraj' ruby in ring. Photo: SSEF
5.01 ct cushion-shaped ruby in ring of artistic design. Photo: SSEF

Sapphires from Kashmir and beyond

Classic sources of sapphire include the famous mining site in the Himalayan range of Kashmir (India), the Mogok Stone Tract in Burma (Myanmar) and the famous deposits of Sri Lanka (Ceylon), known since historic times as the island of gems. Therefore, it is not astonishing that sapphires sold at auction are not only predominantly from one origin (as it is the case for rubies and emeralds), although Kashmir is generally the most appreciated and valuable geographical origin.

In April, Sotheby's HK sold a **Kashmir sapphire of 12.00 ct** (SSEF report 84266) for US$ 1.8 million, and in Geneva in May a **Kashmir sapphire cabochon of 15.34 ct** (SSEF report 80460) set in a Van Cleef & Arpels ring for US$ 2.1 million. A bracelet - also from Van Cleef & Arpels - containing **three Kashmir sapphires** of 6.56, 5.73, and 5.72 ct and matching colour (SSEF report 87878) was sold for US$ 2.5 million by Christie's Geneva in November 2016.

◁ Kashmir sapphire cabochon of 15.34 ct sold by Sotheby's. Photo: SSEF

△ Van Cleef & Arpels bracelet containing three Kashmir sapphires. Photo: SSEF

Further Kashmir sapphires offered at sales in Europe include a **sapphire of 4.58 ct** (SSEF report 87222) set in a ring by Graff, sold in October 2016 by Woolley & Wallis in October for US$ 290'000, and an outstanding **sapphire of 14.13 ct** (SSEF report 88697), sold by Bonhams London for US$ 1.73 million.

△ 14.13 ct Kashmir sapphire auctioned by Bonham's London. Photo: SSEF
Pargasite inclusion in 14.13 ct Kashmir sapphire. Photo: SSEF

Similar to rubies, the sales in Hong Kong have offered a beautiful selection of exceptional and important sapphires from Kashmir, but also further classical sources such as Burma (Myanmar) and Ceylon (Sri Lanka) which all of them sold at high prices.

In June, Tiancheng International sold a **sapphire of impressive size** and weight (34.54 ct) of Burmese origin (SSEF report 84782) for US$ 880'000. Other remarkable sapphires were then sold in Hong Kong in October and November, starting with Poly auctions, selling three exceptional sapphires, each set in a ring with diamonds, such as the oval **Burma sapphire of 27.78 ct** (SSEF report 67243) which sold for US$ 990'000, the **octagonal Burmese sapphire** of 30.03 ct (SSEF report 81613) for US$ 1.8 million, and a **Kashmir sapphire** of an intriguingly lucky weight of **8.88 ct** from Kashmir (SSEF report 65149), which sold for US$ 1.3 million.

△ From left to right: Burmese sapphire of 34.54 ct sold by Tiancheng International. Photo: SSEF - 30.03 ct octagonal Burmese sapphire. Photo: SSEF - 8.88 ct Kashmir sapphire offered by Poly auction. Photo: Poly auction

In November, Bonhams offered a **sapphire of 10.21 ct** set in a ring designed by Mouawad (SSEF report 85262) which was sold for US$ 966'000. And finally Christie's Hong Kong sold a Harry Winston ring with an excellent **Kashmir sapphire of 16.36 ct** (SSEF report 86488) for US$ 2.4 million.

△ 12.00 ct Kashmir sapphire in ring. Photo: SSEF
16.36 ct Kashmir sapphire set in a Harry Winston ring. Photo: SSEF

Blooming emeralds

When it comes to emeralds, a Colombian origin is still the most appreciated, and therefore it is not astonishing that all presented important emeralds at sales are Colombian.

In April, Sotheby's Hong Kong sold an **emerald of 21.96 ct** with no clarity modification (SSEF report 81918) for US$ 630'000. In May, Christie's offered several exceptional emerald items in Hong Kong and Geneva. This included an **emerald ring** by Boghossian (approximate calculated weight 25 ct, SSEF report 68680) which sold in Hong Kong for US$ 1.7 million. Christie's Geneva sold a **loose emerald of 11.25 ct** (SSEF report 87396) reportedly from **Muzo** for US$ 636'000, but the most intriguing items were three emerald necklaces, namely a **multi-gem 'Persepolis' fringe necklace** and ear pendants by Cartier containing emeralds of predominantly Colombian origin, together with unheated Sri Lankan sapphires and cultured pearls (SSEF report 84905) that sold for US$ 1.1 million. A **suite of emerald jewellery** by Cartier, similarly designed

△ Emerald of 21.96 ct with no clarity modification. Photo: SSEF
11.25 ct emerald reportedly from Muzo (Colombia). Photo: SSEF

△ Multi-gem 'Persepolis' fringe necklace and ear pendants by Cartier. Photo: SSEF

△ 19th century emerald necklace of documented provenance. Photo: Sotheby's

as a fringe of graduated emerald bead drops together with diamonds and pearls (SSEF report 84907) for US$ 1.7 million, and finally an **emerald diamond necklace** dominated by a 39.70 ct centre stone from Colombia, accompanied by five smaller Colombian emeralds (SSEF 84906), which sold for US$ 2.88 million.

△ Emerald diamond necklace with central 39.70 ct stone. Photo: Christie's

An impressive **antique emerald necklace** (SSEF report 86414) was sold in November by Sotheby's Geneva for US$ 1.87 million. Based on the Sotheby's catalogue, this necklace in late Victorian style was part of the jewels of the noble family of Doria Pamphilj Landi from Italy, and was presented by Filippo Andrea, Prince of Melfi (1813-1876), to his daughter-in-law Emily at the end of the nineteenth century.

Other important Colombian emeralds sold in Hong Kong include a Harry Winston ring with an untreated **emerald of 11.52 ct** (SSEF report 85222) sold in June at Bonhams Hong Kong for US$ 933'000, an untreated **14.35 ct emerald** (SSEF report 80725) for US$ 1.44 million, and an **artistic emerald pendant** set in a necklace with natural pearls (SSEF report 86904) for US$ 320'000 in Poly auction's autumn sales.

◁ Untreated 11.52 ct emerald Photo: SSEF

△ Emerald pendant set in necklace with natural pearls. Photo: SSEF

Natural pearls at auction

After the frenzy in natural pearls at auction of the past few years, the pearl trade has come back to a more realistic attitude, which is also reflected in auction prices and the quantity of offered items.

Still, there were a few remarkable items sold, including two necklaces, the first offered in April by Sotheby's Hong Kong with **33 pearls** (including one cultured pearl) up to 12.5 mm diameter and partly rosé and green overtones (SSEF report 83463), which sold for US$ 2.4 million, and a **two strand necklace** of 100 pearls (up to 12.80 mm diameter) offered in November by Christie's Geneva, showing a beautifully matching colour subtly ranging from white to slightly cream (SSEF report 87755), which sold for US$ 2.9 million. At the same sale, a beautiful **drop-shaped pearl of 30.31 ct** (SSEF report 84264) sold for US$ 1.6 million, and finally a small but artistic **pearl and multi-gem bee brooch** (SSEF report 86805) of the late 19th century was sold for US$ 30'000.

△ **One-strand pearl necklace with 32 natural pearls and 1 cultured pearl. Photo: SSEF**

△ **Two-strand pearl necklace (100 pearls) up to 12.80mm in diameter. Photo: SSEF**

△ **Beautiful drop-shaped pearl of 30.31 ct. Photo: Christie's**

△ **Artistic pearl and multi-gem bee brooch. Photo: SSEF**

In April, Bonhams London sold a beautiful pair of ear-pendants with **drop-shaped pearls** (SSEF report 83981) of 19 ct each for US$ 182'000. Sotheby's Geneva auctioned a pair of **light brownish grey pearls of 25.05 ct and 24.50 ct** (measured unmounted, SSEF report 87307) set in ear-pendants from the 1920s for US$ 660'000 in November 2016.

△ **Pair of matching drop-shaped pearls sold by Sotheby's HK. Photo: SSEF**

△ **Pair of ear pendants with two 19 ct natural pearls. Photo: SSEF**

In November, Sotheby's Hong Kong sold an **exceptional pair of matching drop-shaped pearls** (SSEF report 84026) for US$ 2.0 million set with diamonds in impressive ear-pendants.

Non-nacreous pearls such as Conch (*Strombus gigas*) have only sporadically been offered at auction so far. An impressive **multi-colour pearl necklace** (including pearls from the Queen Conch and other marine molluscs - SSEF report 81424) was offered in April by Sotheby's Hong Kong but did not find a buyer. Sold, were however, a **conch pearl** (SSEF report 88615) for US$ 61'000 at Phillips Hong Kong, and a **white non-nacreous pearl** of nearly 50 ct (SSEF report 81480) which sold for US$ 25'000 at Woolley & Wallis in Salisbury (UK). This latter pearl showed fine and attractive flame structures, radially emanating from the top of the pearl. We would like to remind readers that the mollusc species from which this pearl originated is currently not determinable, although stated to be from *Tridacna gigas* (Giant clam) in the sales catalogue.

◁ **Conch pearl in ring offered by Phillips Hong Kong. Photo: SSEF**

△ **Two-strand natural conch pearl necklace. Photo: SSEF**

The rare and colourful

The following paragraph highlights a selection of colourful gemstones sold in 2016 at auction beyond the classic gems ruby, sapphire and emerald.

Pink and purple sapphire still belong to the corundum 'family', but are rather rarely offered at auction. Sotheby's (Hong Kong and Geneva) sold a pair of ear pendants in an attractive geometric design with unheated **purple sapphires** (approximately 18.90 ct) from Madagascar (SSEF report 81909) for US$ 112'000, a **pink sapphire** (6.30 ct) of Burmese origin (SSEF report 67864) for US$ 130'000, and an impressive diamond ring with a cushion-shaped **Burmese pink sapphire weighing 10.64 ct** (SSEF report 80462) sold for US$ 305'000. Bonhams London sold another **Burmese pink sapphire of 17.15 ct** (SSEF 84349) set in a Cartier ring for US$ 175'000.

◁ **Burmese pink sapphire of 17.15 ct set in a ring. Photo: SSEF**

In November, Christie's Hong Kong sold a **cat's eye chrysoberyl** of 29.37 ct showing strong chatoyancy (SSEF report 86489) for US$ 89'000, and an outstanding vivid blue Brazilian **Paraiba tourmaline** of 6.43 ct (SSEF report 86834) for US$ 380'000.

△ **Cat's eye chrysoberyl of 29.37 ct showing strong chatoyancy. Photo: SSEF**

△ **Outstanding vivid blue Brazilian Paraiba tourmaline of 6.43 ct Photo: Christie's**

In June, Tiancheng International sold a number of collector gems set by Kat Florence at a charity auction in Hong Kong. Among these jewellery items was the **'Namunyak' tanzanite**, an impressive gemstone of 423.56 ct (SSEF report 84873) with an excellent purity and a deeply saturated blue colour with a purplish tint which sold for US$ 300'000. Another item at the same charity sale was a ring of artistic design containing a cushion-shaped **tsavorite garnet of 51.73 ct** from East Africa (SSEF report 84872) which sold for US$ 167'000. Its beautifully saturated green colour is due to minor amounts of vanadium in the stone, typical and characteristic for this variety of grossular garnet.

◁ **51.73 ct tsavorite garnet in ring. Photo: SSEF**

In December, Bonhams London sold for US$ 70'000 an antique (ca. 1830) cross-shaped pendant containing six **topazes** (up to approximately 21 ct) of highly matching slightly pinkish orange colour and excellent purity (SSEF report 87300). In the trade, topaz of such a colour is also known as 'imperial topaz'.

◁ **Cross-shaped imperial topaz pendant. Photo: SSEF**

And as a final highlight, Christie's Geneva sold for US$ 421'000 an exceptional engraved **Mughal spinel bead** of 128.10 ct from the historic spinel mine at Kuh-i-Lal, located in a remote part of the Pamir mountains in Tajikistan (SSEF report 81037). ✶

△ **Engraved Mughal spinel bead from Tajikistan of 128.10 ct sold by Christie's Geneva. Photo: SSEF**

△ **423.56 ct 'Namunyak' tanzanite mounted in a necklace. Photo: SSEF**

SSEF COURSES
in 2017

2016 was again a busy year for the SSEF Education Department. Our courses have a strong international reputation and we see more and more gemmologists, jewellers and gemstone and pearl professionals from very different countries attending our courses. It's interesting to have participants from so many different gemmological and international backgrounds. In 2017, we will again be offering a wide range of courses. The SSEF Basic Gemmology Course (24 July - 09 August) and the SSEF Basic Diamond Course (02 - 06 October) offer good introductions, and participants can graduate with a certificate after taking theoretical and practical examinations. For more in-depth courses we offer Advanced Training Courses (ATC) on coloured gemstones, pearls and small diamonds. Finally, the Scientific Gemmology Course (SGC) is an ideal course for those interested in learning about the advanced instruments used in laboratory gemmology today.

Advanced Training Course (ATC): Pearls

This three day pearl course takes place twice a year (08 - 10 May; 30 October - 01 November). It is ideally suited for participants (max. 6) who want to know more about how pearls are formed, about possible treatments, and how natural and cultured pearls can be identified and separated. SSEF's important collection of shells and pearls offers a good opportunity for practicing and expanding your skills and knowledge of pearls. The course also offers an introduction into the use of UV-visible spectrometry, EDXRF, X-ray radiography and luminescence for pearl testing in a scientific laboratory.

Advanced Training Course (ATC): Coloured Stones

The advanced coloured gemstone training course is an intense gemmological programme that offers a detailed hands-on approach to identifying treatment and origin of ruby, sapphire and emerald. Please note that this course is always in high-demand, however there are some spots left for the July 2017 course (10 - 14 July 2017). In this course we demonstrate the possibilities and limitations of treatment detection and origin determination of corundum and emerald. Participants will have the opportunity of analysing and testing numerous samples from our collection.

Small Diamond Course

The SSEF small diamond course (08 - 10 November), which focuses on diamonds of a diameter between 0.7 and 3.8 mm, mainly used in the watch industry, enables participants to themselves perform the quality control of such small diamonds. These courses are aimed at people working in the jewellery and watch industry, and can be tailored to your company's specific needs. Previous gemmological experience is welcome but not a requirement.

Scientific Gemmology Course (SGC)

In 2016, the one-week Scientific Gemmological Course will take place 3 - 7 July. During this course, participants learn about techniques and applications of instruments like X-Ray fluorescence spectrometry, UV-Visible-NIR spectroscopy, LIBS (Laser Induced Breakdown Spectroscopy), Raman and FTIR spectrometry in the field of gemmology, as performed at the Swiss Gemmological Institute SSEF. Advanced gemmological education is a requirement.

SSEF 'à la carte' Course

The SSEF Swiss Gemmological Institute can personalise a course based on your or your company's specific requirements. This course format is especially suited for companies that need specific gemmological training for their employees. In 2016, a number of companies have benefited from such courses that were tailored to specific topics including small diamond quality control, diamond treatments or learning to identify coloured gemstones from different origins.

If you or your company are interested, please contact us to discuss how a gemmological course can be tailored to your needs. ✶

△ ATC Coloured Gemstone Course Participants in October 2016. Photo: SSEF

CONGRATULATIONS

The Swiss Gemmological Institute SSEF wants to express its congratulations to the following persons for graduating from the following courses in 2016:

Basis Gemmology Course

- Pornlapas Marenghi
- Marc Grangier
- Bo-Yeon Kwon
- Monika Arnold
- Marco Capeder
- Avant Chordia
- Roberto Romanelli
- David Horstmann
- Frédéric Walter
- Arno Oehlbaum
- Jing Lin
- Stefania Suter
- Cecilia Grilli
- Emilija Petrova
- Irene Monares Robles
- Serena Manzi
- Josyline Kawira

Advanced Gemmology Course

- Jeffery Bergman
- Kris R. Charamonde
- Chunguang Zeng
- Dorian Eckmann
- Alexander Fearnley
- J. Steven Fearnley
- Jeff Politis
- Emma Reeves
- Mélissa Abbas
- Jean-François Moyersoen
- Fabrice Gros
- Chaitanya Vanjara
- Ashutosh Vanjara
- David Abramov
- Annalisa Furini
- Carole Widmer
- Giorgia D'Anza
- Dorotea Rosato
- Alessandra Marzoli
- Federico Baldan
- Max Fawcett
- Leo Criaco
- Jacqueline Hausler
- Mei Yee Giam
- Rachel Evans
- Michael Rytz
- Elena Aapro
- Leslie Chen
- Anastasia Mihailov
- Sara Adams
- David Bosakewich
- He Qiming

Basis Diamond Course

- Manuela Müller
- Linda Schwieger
- Anne Gruaz-Flowerday
- Marco Capeder
- Hilary Rey

Small Diamond Course

- Vishal Bharat Thadeshwar
- Felix Bots

Scientific Gemmology Course

- Clever Sithole
- Carlo Mutschler
- Chen-Luen Li
- Hsin-Han Lai
- Majken Djurhuus Poulsen

SSEF AT SWISS GEMMOLOGICAL SOCIETY MEETING 2016

The 2016 Swiss Gemmological Society (SGS) meeting took place in the Swiss Olympic House in Magglingen, overlooking the beautiful lake of Biel. Jean-Pierre Chalain gave a talk entitled 'Melee and baguette control for the watch-making industry: Authentication and Quality', as a central theme of the conference was the watch industry. Dr. Laurent Cartier spoke about the history of precious corals, current use and production and future outlooks. He also discussed gemmological testing and research projects ongoing at SSEF on precious corals. Dr. Michael Krzemnicki was invited to give two talks, one on recent developments in pearl testing outlining new methods available to study the internal structures of pearls and another talk with an update on outstanding and curious items seen in the past year at the SSEF lab. ✶

NEW SSEF REPORTS AND MYSSEF.CH PLATFORM FOR REPORT VERIFICATION AND DOWNLOAD

NEW SSEF REPORTS

SSEF reports experienced a subtle change in layout in 2016, now coming unfolded and being attached to a detachable supporting cover. This offers simpler storage options for clients as reports can be detached and that they can fit in A4 folder filing solutions. The supporting cover now comes in a uniform blue for all reports replacing the traditional copper, gold and silver coloured backs. Diamond Grading Reports continue to be issued on white report paper whereas Gemstone Reports and Test Reports are issued on cream-coloured paper.

ADDITIONAL SECURITY FOR SSEF REPORTS

Preserving the security of issued reports is a priority for SSEF. Since 2009, all reports issued by the Swiss Gemmological Institute SSEF carry a Prooftag™ label of authentication. This label contains a fraud resistant bubble tag that can only be used once and is impossible to reproduce. The owner of a SSEF report with such a label can check its authenticity online on www.myssef.ch. This newly launched website allows owners to **verify the authenticity of reports and also download PDF scans of these reports.** Reports issued after July 11th 2016 are available on this platform for download. Older reports can continue to be verified on www.prooftag.com or www.myssef.ch but are not available for download.

With this new option, owners can compare the original report with the archived SSEF scan copy of the report. This innovation adds another layer to the security already provided using signature, embossment, lamination and the label affixed to the laminated report. ✶

Step 1: Go to **www.myssef.ch**

Step 2: Click on 'Report Verification'

Step 3: Enter SSEF Report Number and unique Prooftag Reference Number

Step 4: Complete robot check and click 'Verify'

Step 5: Compare Bubble Tag on top right of window with that on your Report

Step 6: Click 'View PDF of report'

Step 7: Click 'Download' (top-right of browser) to download PDF copy of report

Step 8: If you have further reports to verify and download click ' Verify Further Report'

We are certain that the revamped design of our reports and new online report authentication and download options will meet your needs and those of your clients. Should you have any queries regarding the authenticity of a report please do not hesitate to contact us.

SSEF TERMS AND CONDITIONS

SSEF introduced more detailed Terms and Conditions for Gemstone Analysis in 2016. The full Terms and Conditions can be found on the backside of the order form (mandatory when submitting items for testing at SSEF) and on www.ssef.ch/terms-conditions. If no order form is sent with the tested items, testing on the items cannot begin until such a signed form has been received. Please also note that if the insurance part of the order form is not correctly filled out, then SSEF reserves the right to issue and charge the client for insurance for these items whilst at SSEF.

These Terms and Conditions outline the insurance policy on tested items, limitations of testing, warranty, intellectual property and other subjects. We would also like to remind clients that we introduced GemTOF testing in 2016, and reserve the right to carry out this test unless explicitly stipulated by the client that GemTOF testing not be carried out in writing. Please contact us should you have any further questions about testing at SSEF. ✶

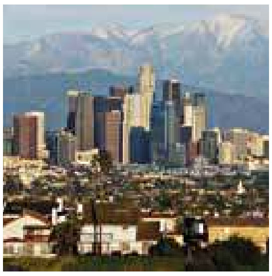
UPDATED INSURANCE POLICY

We would like to remind clients that all items sent to the Swiss Gemmological Institute SSEF for testing need to be insured for all risks by the client. Please note that by signing the SSEF order form, you agree to all terms and conditions and you confirm having an all-risk insurance for your items. This includes the time the item(s) is/are shipped to SSEF, during the evaluation time of the item(s) at SSEF (including possible transport and analysis at an external specialised laboratory) and during the shipment of goods back from the SSEF.

If you do not have such an insurance you can subscribe to one at an additional charge through SSEF, based on the value of the submitted items. Please note that transport insurance is not included in this and must be requested through the transport company. For more information regarding this, please contact SSEF Administration (admin@ssef.ch or tel.: +41 61 262 06 40). ✶

SSEF - FERRARI SHUTTLE SERVICES

We are pleased to announce that the SSEF-Ferrari shuttle service has been expanded to include Los Angeles, Monaco and all destinations in Germany. For all other existing shuttle service destinations please see our website. For destinations not listed in the current SSEF-Ferrari shuttle service please contact us directly for advise on how to best send us your items.



On request shuttle between Los Angeles (USA) - SSEF

(call Ferrari NY office for LA +1 212 764 0676)

Costs: 160.- Swiss Francs flat rate per round trip plus an additional shipping fee of 0.035% on value

Example 1: declared 100'000 SFr > shipping costs: 195 SFr

Example 2: declared 1'000'000 SFr > shipping costs: 510 SFr

NEW!

On request shuttle between Monaco - SSEF

(call Ferrari Monaco office +377 97 70 34 92)

Costs: 160.- Swiss Francs flat rate per round trip plus an additional shipping fee of 0.035% on value

Example 1: declared 100'000 SFr > shipping costs: 195 SFr

Example 2: declared 1'000'000 SFr > shipping costs: 510 SFr

NEW!

On request shuttle between Germany - SSEF

(call Ferrari office in Germany (Ferrari Idar Oberstein +49 711 45 98 420)

Costs: 240.- Swiss Francs flat rate per round trip plus an additional shipping fee of 0.035% on value

Example 1: declared 100'000 SFr > shipping costs: 275 SFr

Example 2: declared 1'000'000 SFr > shipping costs: 590 SFr

NEW!

SSEF FIRST LABORATORY TO OFFER AGE DATING OF PEARLS AS CLIENT SERVICE

The Swiss Gemmological Institute SSEF has become the first gem laboratory worldwide to introduce, as an additional service to clients, age dating of pearls using carbon-14 (^{14}C). This scientific method – also known as radiocarbon dating - can provide the pearl industry with new valuable information about the age of loose pearls and pearls in jewellery.

Age determination can support evidence of historic provenance in the case of antique jewellery and iconic natural pearls. It can also be used to identify fraud in cases where, for example, younger pearls are mounted in historical jewellery items, or have been treated so that they appear older than having been farmed during the 20th century. ^{14}C age dating can be used to obtain evidence to support a decision whether a pearl is of natural or cultured formation. This is because methods to commercially cultivate pearls from certain mollusc species began only during the 20th century.

Radiocarbon age dating of pearls and molluscs started at SSEF in 2008 (Hänni, 2008), always in close collaboration with the Ion Beam Physics Laboratory at ETH Zurich, one of the world's leading universities. Since then, we have analysed natural and cultured pearls, both of historic and present age and published our results in scientific journals (Krzemnicki & Hajdas 2013 https://journals.uair.arizona.edu/index.php/radiocarbon/article/viewFile/16389/pdf) and in the SSEF Facette. The oldest natural pearls examined using this method by SSEF were recovered in the famous Cirebon shipwreck off Java in Indonesia and were dated back to the turn of the first millennium (10th century) (see also SSEF Facette 22, 2016).

Similar to trace element analysis with laser ablation mass spectrometry, age dating of pearls requires minute sampling and as such is not fully non-destructive. By using the latest state-of-the-art instrumentation in Accelerated Mass Spectrometry (AMS), we are able to offer this service by extracting only about 0.01 ct (0.002 g) of nacre of the pearl to be tested. In case of pearls with a drill hole, the sampling is carried out within the drill-hole and thus not visible from the outside.

With this new service, available since February 2017, we are glad to be able to offer a new and valuable service to the international pearl trade. The very positive feedback from the press and trade shows that this new service is considered an opportunity to document the provenance of unique and iconic natural pearls as well as further protecting the natural pearl trade.

For detailed information about terms and conditions for this new service, please check the SSEF website or contact SSEF directly. ✶ **Dr. M. S. Krzemnicki, SSEF**

△ **Figure 1**: Natural pearls recovered from the Cirebon shipwreck in Indonesia dating back to the 10th century, which were identified using 14C pearl method developed by SSEF and ETHZ. Photo: SSEF

△ **Figure 2**: Plastic tube containing a minute amount of nacre powder together with the cultured saltwater pearl from which it was extracted (sampling along the drill-hole at the backside of the pearl). Radiocarbon age dating revealed this cultured pearl (*Pinctada maxima*) to be of rather recent age with a 90% probability to have formed between 1993 and 1996. Photo: SSEF

△ **Figure 3**: As the existing drill hole in this pearl was blocked with a metal lining (glued into drill-hole), we had to drill a small shallow additional drill-hole (diameter 1mm) to extract enough nacre for age dating of this pearl. Photo: SSEF

PEARLSCAN®: A NEW SYSTEM FOR MEASURING PEARLS

PearlScan® is a newly introduced system developed by SSEF that permits to count and measure the dimensions of large quantities of pearls on strands in an efficient manner. Consisting of an A4 scanner, computer and proprietary software this tool offers the pearl industry a new way of documenting pearl necklaces.

At SSEF, we are privileged to receive many outstanding pearl necklaces for testing. These include single strand necklaces and more complex multi-strand necklaces with hundreds of pearls on them. Each pearl is meticulously tested at SSEF by at least two gemmologists before a report can be issued. A report is not limited to whether a pearl is natural or cultured, treated or untreated. Gemmological examination of pearl necklaces also involves carefully counting and taking the measurements of pearls, which can be very time consuming in the case of multi-strand necklaces.

Together with the Centre Suisse d'Electronique et de Microtechnique (CSEM), with whom we have been collaborating for a number of years, we have developed the PearlScan® system which enables users to count and measure the dimensions of large quantities of pearls on strands in a relatively short period of time.

A complex algorithm was developed to detect different strands, count pearls, measure the diameter of pearls, separate pearls from other elements (e.g. knots, diamonds and other decorative elements), calculate a roundness factor for each pearl and measure the length of each strand. The system is semi-automatated so that user intervention is welcomed in order to optimise and review output.

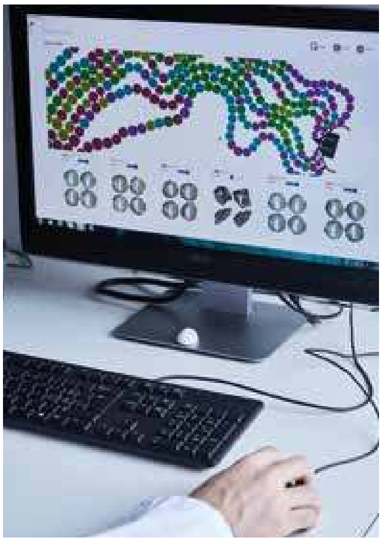
Initially, PearlScan® was developed and tested for our own needs in the SSEF laboratory. The success of the product has led us to now offering this system for sale to the pearl trade. Importantly, because the value of a pearl is also determined by its size (i.e. diameter) it is thus useful for the pearl industry to have an efficient and reliable tool to measure and document the size and number of pearls on single and multi-strand pearl necklaces.

We are convinced that PearlScan® is a viable, efficient and cost-effective product for the pearl industry as it offers:

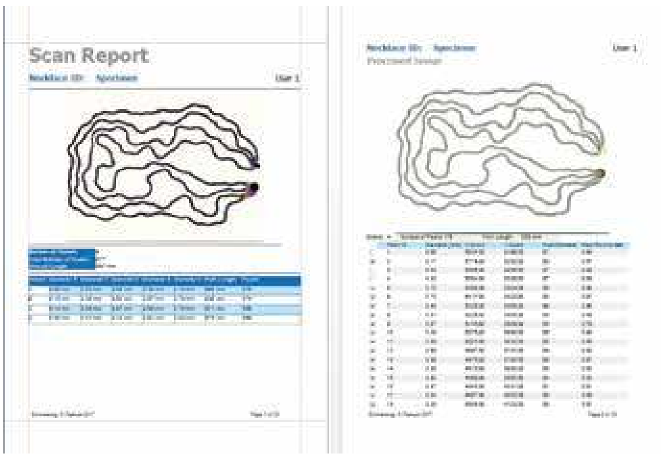
- Ease of use
- Efficient and automated measurement of pearl size (diameter)
- Detailed report of number and diameter of each pearl on each strand
- Documentation image
- Shape roundness factor
- Detailed scan report for documentation

PearlScan® was developed and is now being sold to the pearl trade by SSEF in our mission to develop niche technology for the trade and to support the pearl industry. PearlScan® is sold through SSEF's subsidiary SATT Gems SA. The new system will be unveiled and presented at the BaselWorld show 25-27 March 2017, to fix an appointment please contact us. For more information also visit **www.sattgems.com** ✶ **Dr. L.E. Cartier, SSEF**

◁ **Figure 1:** The PearlScan® system: a scanner to acquire pearl image data, a computer to perform the assessment and measurement, and a user interface to present results and allow user input. Photo: SSEF



◁ **Figure 2:** The user interface of PearlScan® that permits the user to review the scan before counting and measurement of pearls on a multi-strand necklace takes place. Photo: SSEF



△ **Figure 3:** The first two pages of a measurement report of a four-strand pearl necklace with 677 pearls as delivered by PearlScan®. The report delivers a summary, number of strands, number of pearls, diameter of each single pearl and a roundness factor for each pearl.

SMALL COLOURLESS DIAMOND TESTING - UNDISCLOSED SYNTHETICS IDENTIFIED AT SSEF

In last year's Facette, we reported that SSEF found some natural diamonds in synthetic diamond batches purchased for reference purposes. Unfortunately, in May 2016 SSEF found the first undisclosed colourless synthetic diamond in a batch of melees. It was HPHT grown and was first screened by ASDI and in a second stage identified by the typical presence of its nickel-related photoluminescence peaks at low temperature. Since then, every month SSEF detects synthetic diamonds in lots and the following resumes the situation.
Undisclosed synthetics were only found in melee batches, never in baguettes. So far, all of them are HPHT grown, hence SSEF's decision to acquire a PhosView™ in December 2016. All of the undisclosed synthetics were transparent to SWUV light, therefore referred by the ASDI machine. Their sizes range from 1.2 mm to 1.7 mm. Their clarity is always VVS or better and surprisingly, the percentage of synthetics found in a batch is always extremely low (less than 1 per mil). Their colours range from E to J with all of them exhibiting a typical bluish hue. They are of type IIb with a very low boron concentration. Finally, they show strong phosphorescence when observed with the DiamondView™ instrument with typical cub-octaedron growth patterns. ✶ **J.-P. Chalain, SSEF**

TESTING COLOURLESS SMALL DIAMONDS - PROCEDURE

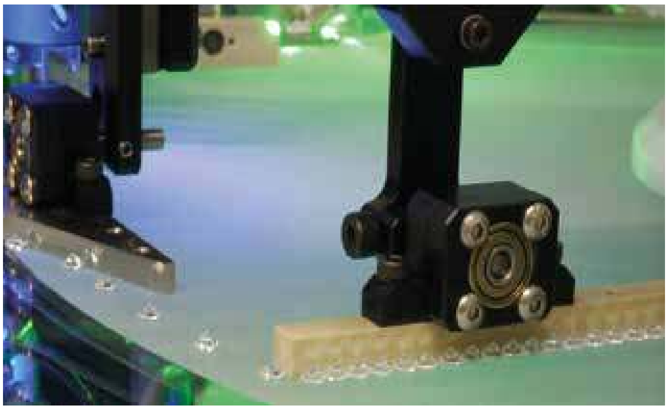
SSEF has been testing colourless small diamonds since 2004, firstly for their authenticity and secondly for their quality. Here we will focus on describing the current situation for authenticating small diamonds. The challenge is dual, since diamonds are tested in large quantities and each single stone is small (diameters down to 1.0 mm for melees).

Each single baguette (any fancy, step cut) will be tested individually by microFTIR (see Facette 2016) and if the test does not show that it is not a diamond of type IaAB with B', it will be further tested for its photoluminescence properties at low temperature (- 196°C).

The situation for round small diamonds is different since the quantities are much larger. Upon request of the client, melee batches will be tested either by sampling or entirely. The first test carried out is the PhosView™, screening any possible colourless HPHT synthetic diamonds; any such candidate will be further tested with the DiamondView™, the LUMOS (see Facette 2016) and eventually by photoluminescence at low temperature (PL). Because the PhosView™ instrument can neither detect the presence of CVD synthetic diamonds nor of HPHT treated diamonds, all none-phosphorescent diamonds (the vast majority in a parcel of natural diamonds) will be checked by ASDI for their short wave UV transparency. None-phosphorescent diamonds will be checked by ASDI for their short wave UV transparency.

All diamonds positively identified by the instrument as natural diamonds of natural colour will be delivered back to the client in a separate bag. Depending on the rate of SWUV transparent diamonds found by the ASDI and on the client's policy, PL testing will be eventually performed on diamonds referred by ASDI.

In case a diamond is screened as a possible synthetic diamond it will systematically be checked for observations, colorimetry measurement, PhosView™, DiamondView™, FTIR, SWUV transparency and PL. ✶



A distribution arm regulates the distance between two diamonds on the automated ASDI diamond sorting machine developed by SSEF and SATT Gems. Photo: SSEF

NEW INSTRUMENTS AT SSEF

Portable Raman

For the past few years, the SSEF has been working in close collaboration with the Electronic Laboratory of the Physics Department at the University of Basel. This collaboration has been very fruitful for the development of new analytical instruments, such as the portable UV-Vis spectrometer, the ASDI our high-tech melee diamond sorting machine, and more recently, the development of a portable Raman spectrometer. Equipped with a ND-YAG solid state laser (532 nm emission) and an Avantes Raman spectrometer, this small and handy instrument is part of our equipment for on-site testing. It is especially helpful for gemstone identification, pearl colour authentication and the separation of jadeite from omphacite and other members of this extensive isomorphous series of pyroxenes. ✶

PhosView™

Upon request of the Indian diamond trade, DeBeers developed a cheap instrument for screening colourless HPHT synthetic diamonds. The low price of the instrument is linked to its simplicity and unfortunately also to its incompleteness in terms of synthetics identification: the instrument cannot identify CVD synthetic diamonds or coloured HPHT synthetic diamonds. Nevertheless, SSEF acquired such an instrument in December 2016. Indeed, this new instrument is currently pertinent because most, if not all, undisclosed melee size synthetic diamonds currently found in batches are HPHT grown, thus identifiable by PhosView™.

The instrument is a desktop model. It runs on a Raspberry Pi operating system and a small drawer will receive up to hundreds of stones. Once the diamond containing drawer is inserted inside the PhosView™, the operator will illuminate the stones with the instrument's ultraviolet short wave lamp, similar to that used in the DiamondView™. The screen displaying the interior of the drawer will show any stone with possible strong phosphorescence, a characteristic of colourless HPHT synthetic diamonds.

When operating the PhosView™, the following limitation of the instrument is very important to understand. Together with the instrument a small colourless synthetic diamond is delivered so as to be used as a phosphorescence reference. It is the experience of SSEF that some colourless HPHT synthetic diamonds of similar size show weaker phosphorescence and therefore, this reference stone shall be used as an indication but not as the weakest possible phosphorescence. The user should also seriously consider the existence of phosphorescent colourless natural diamonds. ✶

PhosView™ instrument in operation at SSEF. Photo: SSEF

Close up:

JUDITH BRAUN HEAD OF ANALYTICS AT SSEF

Our service to clients relies strongly on our analytical expertise in applying state-of-the-art instruments. As such, our analytical department is a core unit at SSEF with staff members accumulating many years of experience in gemstone and pearl testing.

This year, I would like to introduce you to Ms. Judith Braun, who has been working at SSEF since beginning of 2012 and who was appointed Head of Analytics in 2013. With her strong analytical background she is a very important member of our team and has been closely involved in the development of our laboratory over the last few years.

Judith started her professional career as a laboratory chemist at Evonik Industries in Germany, where she was also responsible for quality management of analytical processes and training and security officer for the laboratory staff. Since her arrival at SSEF in 2012, the analytics department of the laboratory has seen several major transformations, including the relocation into much bigger and more modern premises in January 2015 and the integration of new analytical procedures and instruments. In all these moments, we could trustfully rely on her professional management resulting in a very smooth and highly effective implementation over all these years.

The last few months have been again very intense for the analytics department at SSEF, with the integration of numerous instruments such as GemTOF, digital X-ray radiography (Yxlon Cougar), PearlScan®, and a series of mobile instruments assisting us during our on-site testing periods. With her strong background in analytics, she has successfully integrated these instruments in our standardised laboratory procedures and besides that trained several new staff members which joined the SSEF team recently.

Judith Braun takes analytical challenges with a very sportive mind, probably due to her former career as professional basketball player, which made her also a member of the German basketball team at the beginning of the millennium. Being a very committed team player during her sports career, she has transferred this ability excellently to SSEF, as she closely works together with the colleagues in analytics and gemmology at SSEF.

Judith has a family background in the Netherlands - a country of orange flowers, iconic wind mills, and talented football players, which has become a place much more familiar to us especially after the latest famous Edamer cheese tasting at SSEF. ✶ **Dr. M. S. Krzemnicki, SSEF**

TEAM ACHIEVEMENTS IN 2016

We would like to congratulate three of our gemmologists on successfully passing their FGA diploma examinations in 2016. Sebastian Hänsel, Alexander Klumb and Dr. Tashia Dzikowski all received the prestigious FGA diploma in the summer of 2016. We continue to support our longstanding collaboration with Gem-A, and find that the FGA is an ideal addition to the solid mineralogical and earth sciences university training of our gemmologists. ✶

COLLABORATION WITH THE UNIVERSITY OF LAUSANNE

Dr. Laurent E. Cartier has been a lecturer for gemmology at the University of Lausanne's Institute of Earth Sciences since 2014, following good work done there by Prof. Henry Hänni in earlier years. His teaching activities include gemmology both in theory and practical workshops, and an annual excursion to Idar-Oberstein. These courses are offered to Master level students through the Joint Geneva and Lausanne School of Earth Sciences (ELSTE). The feedback and enthusiasm of students in the past years for these courses have shown that gemmology is an excellent complementary subject to other disciplines studied within the earth sciences curriculum. The University of Lausanne has in the meantime also purchased a useful and complete collection of gemstones that can be used by students for training and research. The collaboration with University of Lausanne is also ideal as it gives us access to innovative instruments and leading researchers to work with on ongoing research projects. ✶

COOPERATION WITH THE INSTITUTE OF EARTH SCIENCES, UNIVERSITY OF GRAZ

The SSEF is pleased to announce a cooperation agreement with the Institute of Earth Sciences of the Karl-Franzens University of Graz in Austria. Since autumn 2016, Sebastian Hänsel -SSEF gemmologist- started giving lectures in basic practical gemmology in Graz. Furthermore, SSEF is supporting the Institute of Earth Sciences with basic equipment such as refractometers, polariscopes, tweezers and loupes. The SSEF is also helping to build up a course collection of gemstones for teaching purposes at the University of Graz. Such gemmology courses will take place at least every two years.

Future scientific research cooperation on important issues of gemstone formation and treatments is also planned. Dr. Christoph Hauzenberger, our research partner at Karl-Franzens University, is a well-known scientist with recent publications in Gems & Gemology and Journal of Gemology. ✶

PEARL LECTURE AT CSEM WORKSHOP

Since a few years, the SSEF has been collaborating with the Swiss Centre for Electronics and Micotechnics CSEM in several R&D projects. As a result of our joint-study about the application of X-ray phase contrast and small scale scattering imaging of pearls, Dr. Michael S. Krzemnicki was an invited speaker at the CSEM workshop about 'industrial non-destructive inspection by X-ray phase contrast imaging' at the Technopark in Zurich in September 2016. His presentation focussed on the latest results of our research in pearl analysis and authentication at SSEF. ✶

SEMINAR IN HONG KONG: RESPONSIBLE PRACTICES IN CORAL AND PEARL INDUSTRY

CIBJO and the Italian Trade Commission organised a seminar on responsible practices in the coral and pearl industry. This seminar took place during the 2016 March Hong Kong International Diamond, Gem & Jewellery Show and focused on the implementation of environmentally sound practices in both the coral harvesting and pearl farming sectors. Dr. Laurent E. Cartier was invited to give an overview talk on corporate social responsibility and sustainable marine practices in the pearl industry. Other speakers of this engaging seminar included Dr. Gaetano Cavalieri (CIBJO), Paula Guida (Italian Trade Commission HK), Enzo Liverino (CIBJO Coral Commission), Russell Hanigan (Paspaley Pearls, Australia), Jacques-Christoph Branellec (Jewelmer, Philippines), George Lu (CIBJO Coral Commission) and Dr. Cristina Del Mare. ✶

△ **Hong Kong March seminar participants. Photo: CIBJO**

GEMMOLOGY LECTURE IN CHINA

In the beginning of September 2016, our senior gemmologist Dr. Wei Zhou gave a lecture on 'International Gemstone Testing' at the School of History, Nanjing University, Nanjing, Jiangsu province China. Nanjing University is one of the oldest University in China and ranked No. 3 in China and No. 28 worldwide around all institutions (based on 2015 Nature Index). As one part of their humanities and cultural quality training programme in the School of History, Nanjing University, Prof. Jianqiu Huang invited her to give a lecture to discuss cultural relics authentication but with a focus on gemstones. Over 250 participants joined this 3 hour presentation about rubies, sapphires and other interesting gemstones. ✶

CIBJO CONGRESS 2016

The World Jewellery Confederation congress took place in the old city of Yerevan in Armenia October 26-28 and was hosted by Armenian Jewellers Association (AJA). Invited by Dr. Gaetano Cavalieri, President of CIBJO, the president of Armenia Serzh Sargsyan honoured the congress through his presence and delivering a warm welcome speech.

Aside from the three official congress days, many committee members worked hard in contributing to updating the diamond book, the gemstone book, the pearl book, the coral book and other books in pre-congress meetings. Updated versions of the CIBJO blue books can be downloaded from the CIBJO website (www.cibjo.org, tab 'blue book'). ✶

GEMMOLOGICAL SESSION AT CIBJO CONGRESS 2016: PIGEON BLOOD RED AND ROYAL BLUE CRITERIA AND HARMONISATION PRESENTED BY SSEF

In October 2016, Dr. M.S. Krzemnicki was invited as a speaker to the annual CIBJO Congress, this time held in Yerevan, the capital of Armenia. The presentation was part of a Special Gemmological Session about inconsistencies of gemstone reports, organised by Dr. Hanco Zwaan, President of the Gemmological Commission at CIBJO.

Dr. Krzemnicki's lecture focused on colour trade terms, namely 'pigeon blood red' and 'royal blue', and revealed in detail the strict criteria in terms of colour (using master stones) and quality required to qualify for these terms at SSEF. It further explained the agreement SSEF and Gübelin reached in 2015 to harmonise their criteria with the aim of reducing colour related inconsistencies on lab reports (see also SSEF Facette No. 22, 2016, pages 8-10). The lecture closed with an outlook and invitation to other laboratories to participate in this agreement with the aim of creating worldwide harmonised criteria.

The presentation was warmly received by the attendees and representatives of the international trade present at a Special Gemmological Session. From the feedback we received, we are convinced that our standardised use of these terms is for the benefit of the international gemstone trade and will foster a responsible and meaningful application of these terms in the trade now and in future.

For more detailed information, please download the complete presentation on our SSEF website:
http://www.ssef.ch/research-publications/presentations/coloured-gemstones/

SSEF AT SWISS GEOSCIENCE MEETING IN GENEVA

14th SWISS GEOSCIENCE MEETING 2016 GENEVA

SSEF staff presented three talks at the Swiss Geoscience Meeting 2016 in Geneva on 19th November 2016. SGM had again this year a session dedicated to gemmology that was convened by Dr. Laurent Cartier and Dr. Michael Krzemnicki. Talks included Dr. Hao Wang (SSEF) speaking on use and recent research of GemTOF in gemmology. Prof. Leander Franz (University of Basel) presented research on Sannan Skarn. Dr. Michael Krzemncki showed results of a 3D visualisation study of inclusion features in emerald with neutron and X-ray tomography. Finally, Dr. Laurent Cartier spoke about treatments and origins of golden South Sea cultured pearls. The 2017 edition of the Swiss Geoscience Meeting will be held in the mountain town of Davos, where again a gemmology session will be organised. ✶

PEARL FORUM AT INHORGENTA

Inhorgenta Münich organises an annual Pearl Forum, moderated by Dr. Laurent Cartier. The aim of the forum is to share pearl industry developments with a wider audience. 2016 marked the third edition of this forum with the theme of 'South Sea Pearls', as 2016 marked the 60th anniversary of South Sea pearl production. Speakers included Peter Bracher (Paspaley Pearls, Australia) who showed a clip of the impressive film The Secret Life of Pearls and spoke about the Australian pearl industry. Other speakers were Jörg Gellner (Gellner, Germany), Phil Bouasse (Devarieux Designs, Hong Kong & Paris) and Liza Urla (Gemmologue, UK). The 2017 edition on February 19th focused on 'Unconventional Pearls' with talks discussing Mexican pearls (Douglas McLaurin, Cortez Pearls), natural pearls (Dr. Hubert Bari, France), online sale of pearls (Jeremy Shepherd, USA), innovative designs in pearls (Melanie Georgacopoulos, UK) and as a final highlight a screening of footage from the new documentary film Power of Pearl (USA). ✶

75TH ANNIVERSARY OF SWISS GEMMOLOGICAL SOCIETY

The Swiss Gemmological Society (SGS) is celebrating its 75th anniversary in 2017 and is organising a conference in Zermatt 29 June – 1 July for this special occasion, which will also act as a European Gemmological Symposium (EGS). The two-day conference will cover a wide range of topics from coloured gemstones, diamonds and pearls. The focus will not only be on scientific gemmology but also topics such as mining, jewellery history and new appearances in gem sources and treatments. Notable speakers include Martin Rapaport, Bruce Bridges, Alan Hart, Dr. Uli Henn, Dr. Raquel Alonso-Perez, Dr. Joseph Taylor, Vincent Pardieu and others. Zermatt, one of the most picturesque villages in Switzerland with the famous Matterhorn mountain in the background will be a grand venue for this memorable conference. This conference can also be attended by guests, for more details visit **www.gemmologie.ch** ✶

△ **75th anniversary SGG conference will take place in Zermatt in the Swiss Alps late June. Photo: Wikipedia**

IGC 2017 IN NAMIBIA

△ **IGC 2017 will take place in Windhoek, Namibia. Photo: Dr. U. Henn**

The last International Gemmological Conference (IGC) took place in Lithuania in 2015 (see Facette 2016). The next conference will take place in Windhoek, Namibia in October 2017. The organising committee for this conference is led by Dr. Ulrich Henn of the German Gemmological Association, assisted by Prof. Henry Hänni and local partners in Namibia. SSEF gemmologists continue to be involved in IGC activities and will also travel to this leading international conference for gemmology. Information about the upcoming conference in Namibia can be found at **www.igc-gemmology.org** ✶

SSEF ON-SITE IN 2017

In 2017 we will be exhibiting and/or offering our on-site testing services as follows :

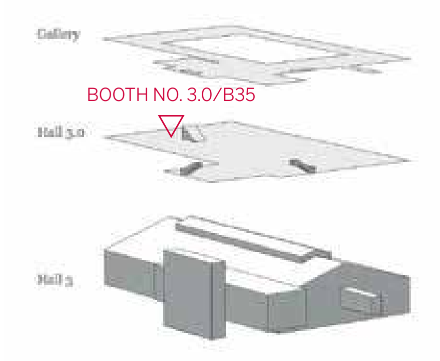
Hong Kong	23 February - 06 March
BaselWorld	23 - 30 March
Bangkok	15 - 19 May
Hong Kong	19 - 25 June
Bangkok	21 - 25 August
Hong Kong	08 - 19 September
Paris	on request

Further on-site services will be communicated through our website and in newsletters. Please subscribe to our newsletter on our website www.ssef.ch to be updated regularly about our on-site schedules, other services and news. ✶

BASELWORLD 2017

During BaselWorld 2017 (23 - 30 March), the SSEF will be once again offering its convenient gemstone and pearl testing services.

You can find us in the ground floor of Hall 3 at booth No. 3.0/ B35, at the same location as in past years. The phone number at our booth (+41 61 699 51 29) remains the same, as does our high-quality express service, which may even include a nice cup of coffee and some Swiss chocolate. We are looking forward to meeting you at our booth and to testing your gemstones and pearls during the Basel Show. If you would like to have a number of items analysed, we suggest you call us in advance at the SSEF office (tel. +41 61 262 06 40) to fix an appointment. This is also strongly suggested if you would like to have your items tested shortly before the show. ✶



△ Photo © BaselWorld 2013.

SSEF IN ASIA

Our presence in Asia was very successful in 2016, as our services have gained importance for clients in the Far East and South East Asia, who ask for accurate and internationally renowned reports.

In 2017, the Swiss Gemmological Institute SSEF will again offer its services at two locations in Asia:

Bangkok

In Bangkok, we will be testing your prestigious gemstones in our Bangkok office at Silom road between 15 - 29 May and 21 - 25 August. Please subscribe to our newsletter on our website www.ssef.ch to be updated regularly about our on-site schedules, other services and news.

Bangkok
dates
to remember!

Hong Kong

The last year has again shown how important Hong Kong has become as a major hub for the gemstone and jewellery trade. Since many years, the SSEF is offering its services in Hong Kong for the local and international trade of prestigious gemstones and jewellery. In 2017, we will again be very active in Hong Kong, offering services at the three main Jewellery Shows in March, June and September (at AsiaWorld Expo and at the Convention Centre), but also at our location in Central during several preshow periods. This pre-show testing service is only by appointment, so please contact us (phone +41 61 262 06 40, asia@ssef.ch) if you need further information about our Hong Kong services or to confirm an appointment. Apart from offering our on-site services regularly in Hong Kong, you may also use the reliable SSEF-Ferrari shuttle services to send us your gemstones, pearls or jewellery smoothly to the SSEF (for details, see shipping instructions on the services section of our website www.ssef.ch). ✶

Hong Kong
dates
to remember!

DONATIONS

As in previous years, we are grateful for numerous donations we received in 2016 from many pearl and gemstone dealers around the world. These donations not only support our research but also add to our collection of specimens to be used in our courses, with the aim to educate the participants and to give them the opportunity to learn gemstone & pearl testing on a wide variety of untreated and treated materials.

We would like to especially thank the following persons and companies:

FOR PEARL DONATIONS:

Jeremy Norris (Oasis Pearls, USA), Jörg Gellner (Gellner, Switzerland), Marco Giovanardi (Milleperle Ltd., London), Sue Hendrickson (USA), Justin Hunter (J. Hunter pearls, Fiji)

FOR GEMSTONE DONATIONS:

Philippe Honegger (Switzerland), Henry A. Hänni (GemExpert, Basel), Vladyslav Yavorskyy (Hong Kong), Michael S. Krzemnicki (Basel), W. Balmer (Collection Balmer, Switzerland), Ronny Totah (Horovitz & Totah, Switzerland), Avia Nathanel (Fancy Collection, Hong Kong), Fritz Walz (Reishauer, Switzerland), Joseph Belmont (K.V. Gems, Bangkok), Daniel Simonin (Bolli Goldschmied, Switzerland), Ruwanpura Gems (Sri Lanka), Aung Kyaw Zin (SP Gems, Myanmar), Yianni Melas (Cyprus), Mie Mie Tin Htut (Silkeneast Co. Ltd, Bangkok), Mr. Ko Choo (Mogok, Myanmar), Kyaw Swar Tun (AGGL lab in Yangoon, Myanmar), Z. Buzas, H. Brunner, A. Fiedler, N. Bhusal ✶

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△ Visit of Beyeler Foundation in Basel during SSEF team event. Photo: SSEF

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