On the Trail of New Gem Deposits:

Exciting for the Trade but Challenging for Gem Labs

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Coloured gemstones were formed during large-scale geological processes which have shaped the world as we know it today...
The collision of the Indian plate with the Eurasian plate has produced some of the most important deposits for coloured gems, such as in Kashmir (India) for sapphires, in the Pamir mountains (Tajikistan) for spinel, and in Mogok (Myanmar) for rubies and sapphires, to name a few.
Gemstones form by geological processes. They seal within them a record of their specific formation history and conditions. It is the work of gemmologists to unveil this record...

Cascade of tiny solid inclusions accentuated by blue colour haze in a sapphire from Madagascar
Internal features may be very characteristic for a specific provenance of a gemstone, and thus being a valuable proof for its origin. But these features may also be of exquisite beauty and add to the uniqueness of a gemstone.
Some gem sources are known since historic times. Their gems have been treasured over centuries for their beauty and rarity, and they are thus highly sought after by the market today.
But where do the stones come from...
Small scale and artisanal mining:

Ruby deposit in marble rocks in Mwarasi (Tanzania)
remote and adventurous...

Spinel deposit in marble rocks near Mahenge (Tanzania)
Only few large and mechanised mine operations

Emerald deposit in Zambia (Gemfields)
Mining of Coloured Stones vs Mining of Diamonds:

Diamonds from different mines often show very similar range of colours and qualities. The diamonds from different mines are commonly and deliberately mixed, as they are only/mostly sold based on their quality (4C). There is commonly no price difference for diamonds from a newly found mine compared to diamonds from a established production.

There is not much incentive (so far) to separate diamonds from different sources.
Mining of Coloured Stones vs Mining of Diamonds:

Coloured gemstones often show **mine specific** colour shades or visual qualities. This makes every new find interesting, as even new colours or gem varieties (e.g. Paraiba tourmaline) may be discovered.

It brings very innovative aspects into the trade, as new deposits bring the chance to acquire gems at a substantially lower price (at least in the beginning of production) than from reputed and historic deposits. Thus it may provide the option for new stakeholders to enter the gem trade with only limited financial power; the only need is to be „among the first“ at a new gem discovery.

There is a strong demand for independent origin determination in the trade, as the origin of a gem may have a positive (or negative) impact on its price.
Sapphires of excellent quality from a new deposit at Bemainty near Ambatondrazaka (Madagascar), discovered October 2016

Such new gems may be comparable to...
...sapphires of finest quality from historically reputed deposits

The Star of Kashmir, 19.88 ct
Sold at Christie’s in Geneva, May 2013 for 3‘500’00 mio US$
The Challenge to Determine the Origin of Gems

For gemmological laboratories offering the service of origin determination, it is thus crucial to quickly adapt to new developments and discoveries:

- Get first-hand reliable samples, and if possible, from the mining site.

- Get an overview about production, quality, sizes, availability...

- Establish a catalogue of characteristic properties and internal features.

- Check for (geological and gemmological) similarities with existing gem deposits and develop methods to separate gems from a new deposit from existing ones.

Most important is to be able to separate gems of a new source from those originating from highly prestigious and classic sources.
The Challenge to Determine the Origin of Gems

Distribution of corundum deposits connected to Pan-African tectono-metamorphic events (750-450 ma) caused by the collision of eastern and western Gondwana.

In mid-Jurassic (about 160 ma), India started to drift towards north.

Guilliani et al. 2007
The Challenge to Determine the Origin of Gems

Formation of rubies in marbles

Mogok, 2016
Analytical instruments for origin determination at SSEF

- X-ray fluorescence (EDXRF)
- Raman microspectroscopy
- FTIR Infrared spectroscopy
- UV-Vis-NIR absorption spectroscopy
- Laser-induced photoluminescence
- GemTOF (laser ablation ICP time-of-flight mass spectrometry)
Rubies from Mozambique

the Eyes of the Dragon (11.26 ct and 10.70 ct)

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Rubies from Mozambique

Since their discovery in early 2009, the ruby deposits near Montepuez in Mozambique have produced an impressive number of exceptional-quality stones.

Scarlet Drop (15.95 ct)

Rhino Ruby (22.04 ct)
Detection of „Low-Temperature“ Heated Mozambique Rubies

In more recent years, an increasing number of rubies from Mozambique have come onto the market, after having undergone so-called “low-temperature” heating (below 1000 °C).

Unheated ruby from Mozambique showing a slight purplish zone which can be removed by low-T heating (< 1000°C).
Detection of „Low-Temperature“ Heated Mozambique Rubies

Characteristic microscopic features indicating a heat treatment such as a small disc-like expansion fissure (above) and a tiny heat-induced fissure at the surface (below) in heat treated Mozambique rubies.

But not all of these heated rubies show the microscopic features that commonly characterise heat treatments. This is a situation that challenges gemmologists and gemmological laboratories, and also, ultimately, the trade.
Detection of „Low-Temperature“ Heated Mozambique Rubies

New research at SSEF on a large number of unheated and heated Mozambique rubies reveals that, rather than using individual FTIR peaks to determine if a ruby has been heat-treated or not, the focus should be on peak patterns.

FTIR spectra of unheated rubies from Mozambique (in green, below) and heated rubies (in red, above).

SSEF Press Release Sept 2018
see www.ssef.ch
Emeralds from Afghanistan
Panjsheer Valley

Photo © engulfed.com
Emeralds from a new „pocket“ in Panjeer valley, Afghanistan

Discovered in early 2017, this new find has produced a small quantity of stones of partly exceptional quality.
Emeralds from a new „pocket“ in Panjeer valley, Afghanistan

in many aspects very similar to Colombian emeralds
A new source in Africa: Ethiopia
Emeralds from Shakiso in southern Ethiopia

Newly discovered in November 2016
Emeralds from Shakiso in southern Ethiopia

This new material from Ethiopia can be easily separated by microscope from emeralds originating from the classic mines in Colombia.

But in many aspects - such as formation, properties and inclusions - very similar to emeralds from Zambia and therefore very difficult/impossible to separate from Zambian material just using the microscope.

Advanced instrumentation is necessary!
Emeralds from Shakiso in southern Ethiopia

UV-Vis-NIR absorption spectrum and GemTOF trace element data plot to separate Ethiopian emeralds from Colombian emeralds (very different formation) and from Zambian and other biotite-schist related emerald deposits.
Recently in the spotlight

Sapphires from northern Ethiopia

Ethiopian sapphires show features typical for sapphires from basaltic origin.
Recently in the spotlight

...and from Madagascar

U-Pb age dating may provide in certain cases important information about gemstone formation (and origin)
Recently in the spotlight

...and from Madagascar

New deposit discovered in October 2016 at **Bemainty**, near the small town **Ambatondrazaka**, Madagascar. Mostly sapphires, but also fancy coloured varieties.

Some of the most productive ruby and sapphire mines of Madagascar (adapted from V. Pardieu 2017).
Recently in the spotlight

Fancy Sapphires with unstable Padparadscha-like colour

...so this fancy sapphire will be pink again after few weeks
Recently in the spotlight

Fancy Sapphires with unstable Padparadscha-like colour

Since mid 2017, SSEF applies colour stability test on padparadscha sapphires!

The colour of the stones are analysed before and after UV activation and fading test to determine their colour stability or instability!

In case the tested stone shows a distinct shift, SSEF will not identify these stones as padparadscha, but as fancy sapphire, adding a comment (and explanation letter) about their unstable colour.
Recently in the spotlight

New Sapphires of « Kashmir-like » appearance

See also:
www.ssef.ch/research-publications/press-releases/

and
ICA InColor
June 2017

SSEF Newsletter March 2017-03-27

Trade alert:
‘Kashmir-like’ sapphires from Madagascar are entering the gem trade in large sizes and quantities

by Dr. Michael S. Kremsmiller, SSEF

In the last few weeks, the Swiss Gemmological Institute SSEF analysed an important number of sapphires from a new deposit at Bemainty, near the small town of Ambatondrazaka in Madagascar, which were submitted to us by several reliable independent sources. This new gem-rush in Madagascar has produced in the last few months an impressive amount of sapphires, fancy coloured sapphires, and padparadschas of partly exceptional size and quality (Kremsmiller 2017 in SSEF newsletter www.ssef.ch/research-publications/newsletter/ and upcoming Journal of Gemmology, Perkins 2016, Perkins & Pandieu 2016, Pandieu et al. 2017), and seems to be a new gem source more important than anything we have seen in recent years.

Figure 1: Exceptional quality royal blue (left: 30 cts, right: 35 cts) of ‘Kashmir-like’ sapphires from Bemainty near Ambatondrazaka in Madagascar. Photo: SSEF
The velvety blue of Kashmir sapphires

Sapphires from Kashmir contain sub-microscopic inclusions which scatter the transmitted light.

As a result, these stones often show a highly appreciated **velvety** blue colour.
The Kashmir - Madagascar challenge!
The Kashmir – Madagascar Challenge

The newly discovered sapphires from Bemainty show a milkyness, resulting in an attractive velvety blue colour similar to Kashmir sapphires.

Fine milky zoning in sapphires from Bemainty compared to blocky zoning in Kashmir sapphires.

Madagascar  Madagascar  Kashmir
Distinct colour zonation in sapphire from new deposit at Bemainty (Madagascar)
Kashmir sapphire

The Richelieu sapphires, sold at Sotheby’s Geneva for US$ 8.35 mio.
Pargasite (amphibole), highly characteristic inclusion for sapphires from Kashmir
The Kashmir – Madagascar Challenge

Kashmir

prismatic zircon inclusions in Kashmir sapphires, often slightly corroded.

Ambatondrazaka, Madagascar

tiny prismatic zircon inclusions in sapphires from Bemainty near Ambatondrazaka (Madagascar), visually quite similar to zircons in Kashmir sapphire
The Kashmir – Madagascar Challenge

Raman spectra of zircon inclusions

- Kashmir
- Ambatondrazaka
  Madagascar

non-metamict zircon inclusion
metamict zircon inclusion
The Kashmir – Madagascar Challenge

Analysis of Raman spectra (position and peak width of 1008 cm\(^{-1}\) peak) of zircon inclusions of corundum (ruby/sapphire) from different origins.

Zircon inclusions in pink sapphire

Raman peak at ~1008 cm\(^{-1}\), anti-symmetric \(\nu_3\) (SiO\(_4\)) stretching:

increase in metamictisation
The Kashmir – Madagascar Challenge

GemTOF (Laser Ablation ICP Time-of-Flight Mass Spectrometry) is a very powerful tool to analyse trace elements of gemstones, thus supporting origin determination at SSEF.
Using **machine-learning** algorithms, the statistical difference between the multivariate trace element data of "Kashmir-like" sapphires from Madagascar (in red) and those of Kashmir sapphires (in blue) can be visualized even more clearly.
New gem deposits will be discovered in the future and provide exciting options for the trade but also challenges for gem labs.

But the trade has also a responsibility to strive for a respectful and sustainable mining and supply chain including a correct disclosure towards the consumers.

Gem Labs will assist the trade in these issues.
Thank you for your attention