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INSTITUT SUISSE DE GEMMOLOGIE

On the Trail of New Gem Deposits:

Exciting for the Trade but Challenging for Gem Labs

PD Dr. Michael S. Krzemnicki, Swiss Gemmological Institute SSEF www.ssef.ch

Coloured gemstones were formed during large-scale geological processes which have shaped the world as we know it today...

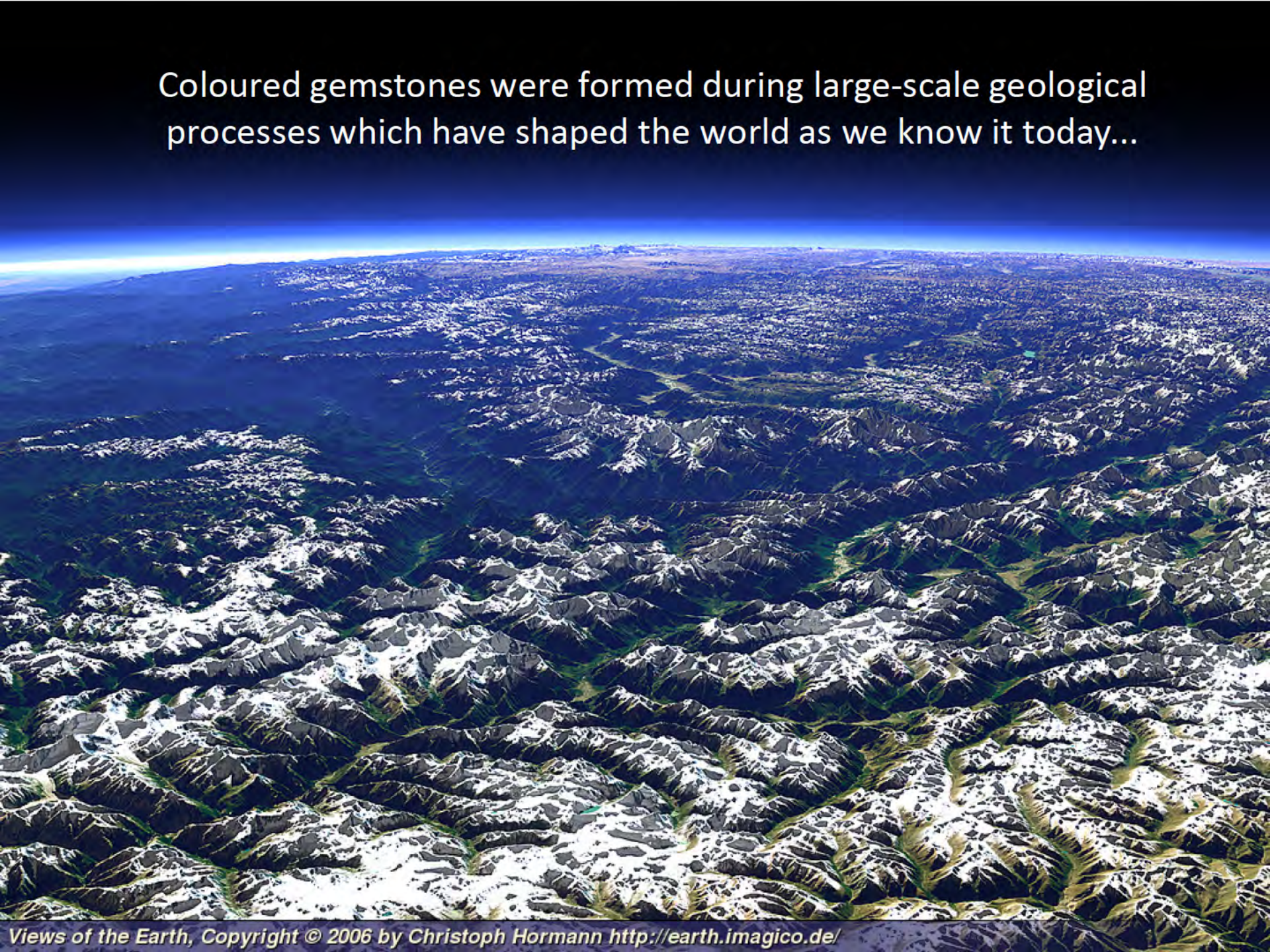
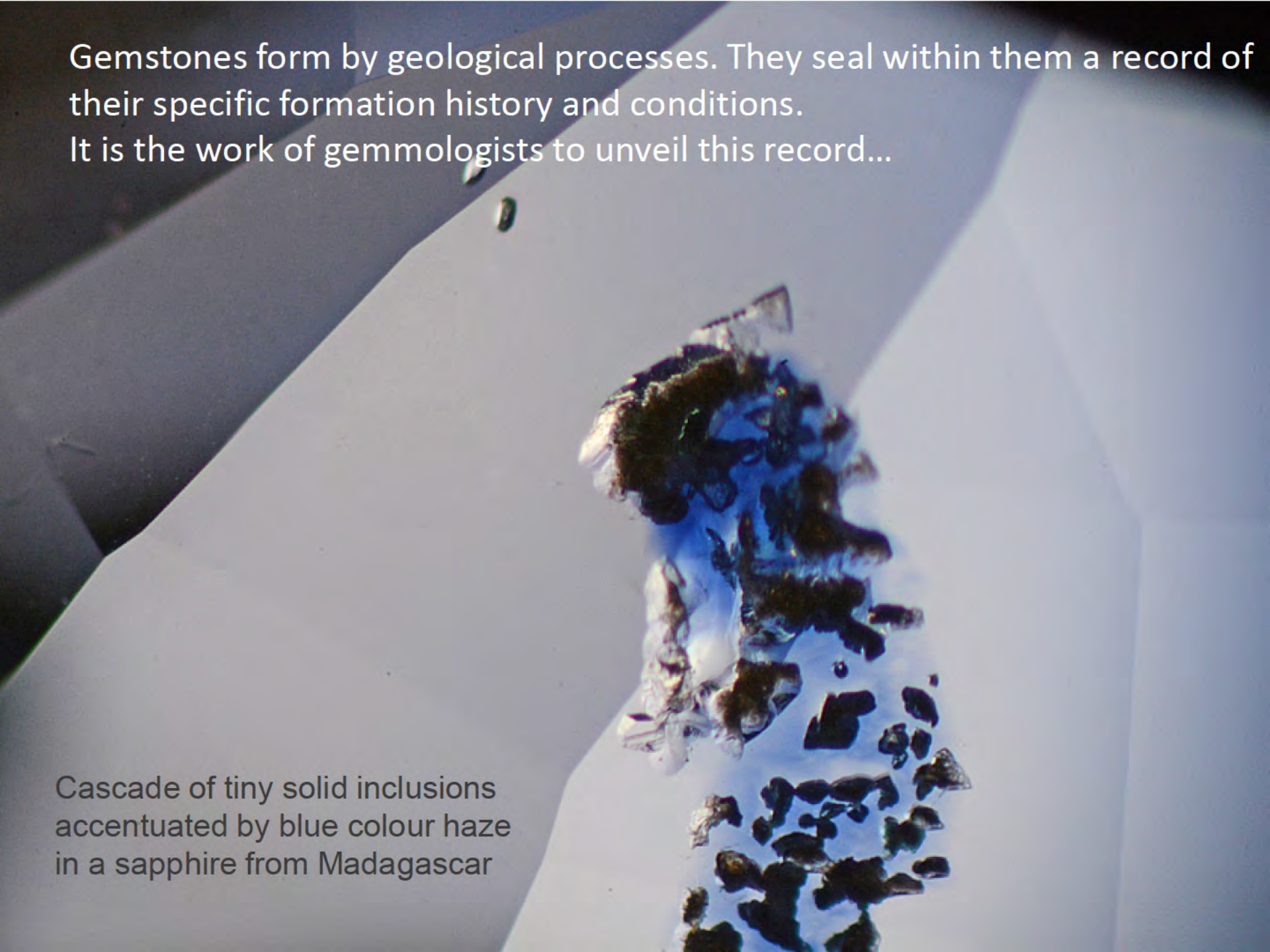


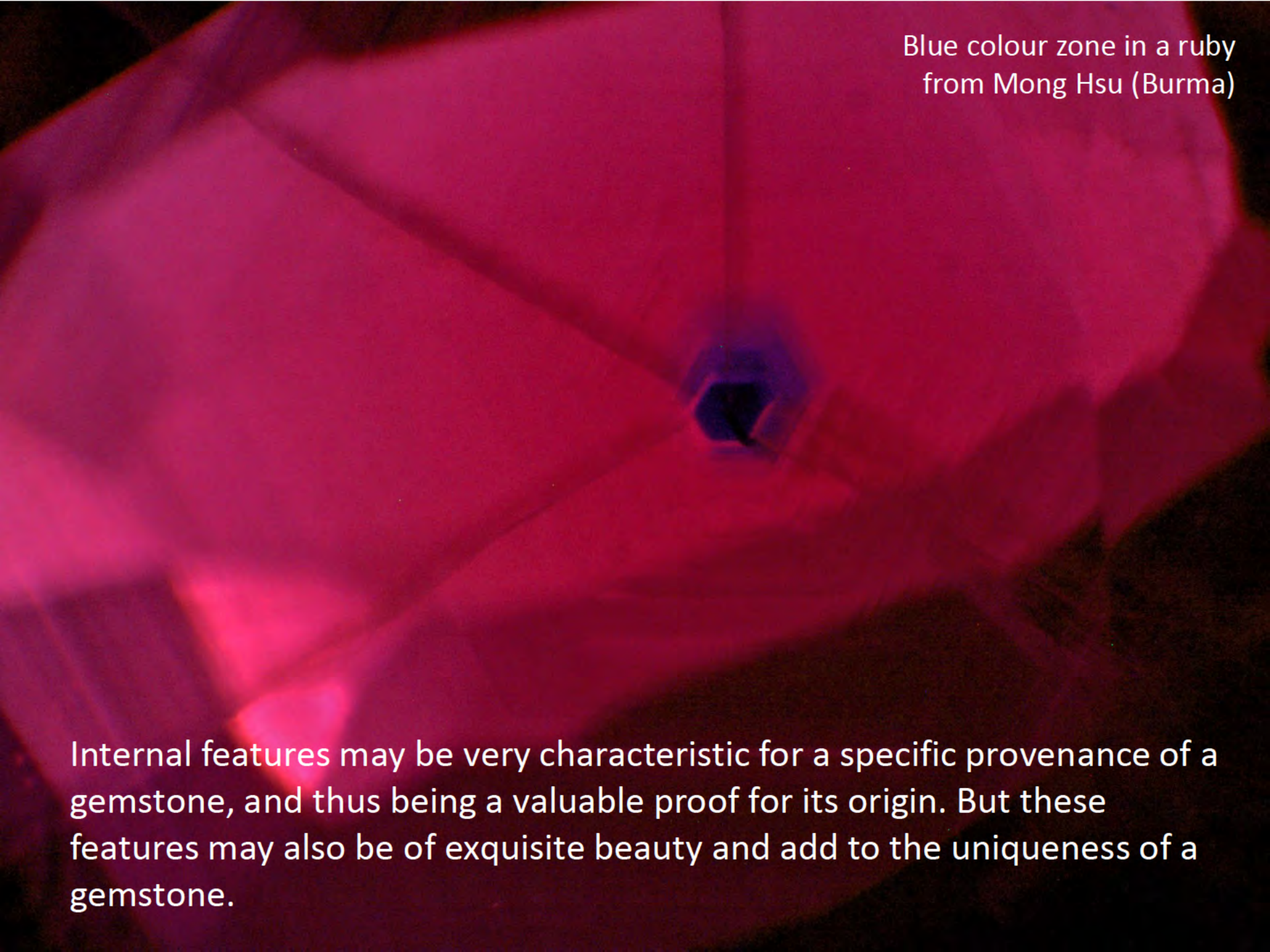
Foto: Baltoro-Glacier, Karakorum; Guilhem Vellut via, WikiCommons

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



Blue colour zone in a ruby
from Mong Hsu (Burma)

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.

The King of Burma, circa 1885

Bagan, Burma © P. Boegli, Flickr.com

But where do the stones come from...

Andranondambo in southern Madagascar

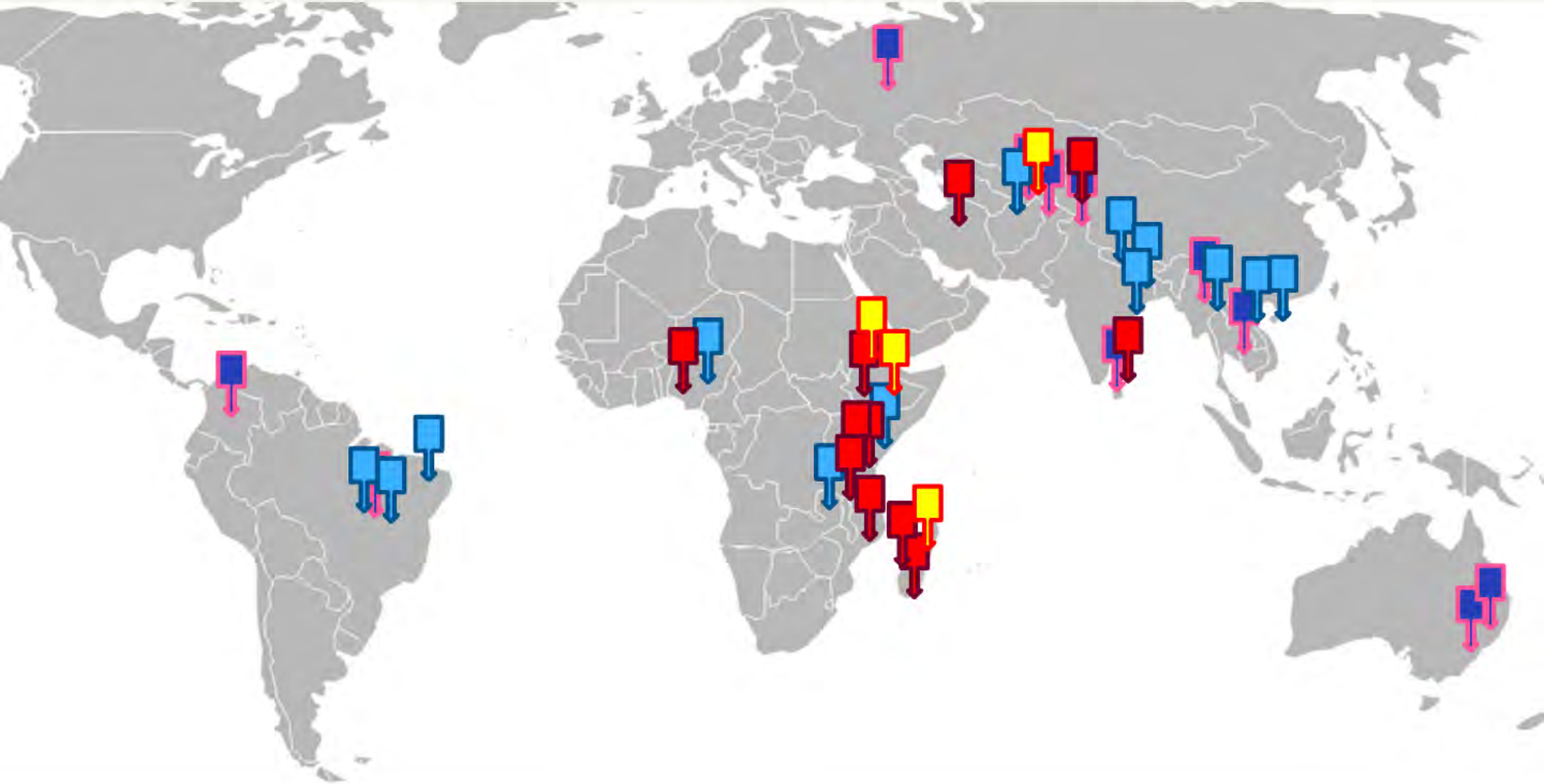
Gem Deposit Discoveries

historic still active

discovered 1960-2000

discovered 2000-2017

discovered in the last few months



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Small scale and artisanal mining:

Ruby deposit in marble rocks in Mwarasi (Tanzania)

clip

remote and adventurous…

Spinel deposit in marble rocks near Mahenge (Tanzania)


PEPSI
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Only few large and mechanised mine operations

Emerald deposit in Zambia (Gemfields)

Photo courtesy Gemfields plc

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.

Photo courtesy Natural History Museum, London

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$

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The Challenge to Determine the Origin of Gems

For gemmological laboratories offering the servic
origin determination, it is thus crucial to quickly a
new developments and discoveries:

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

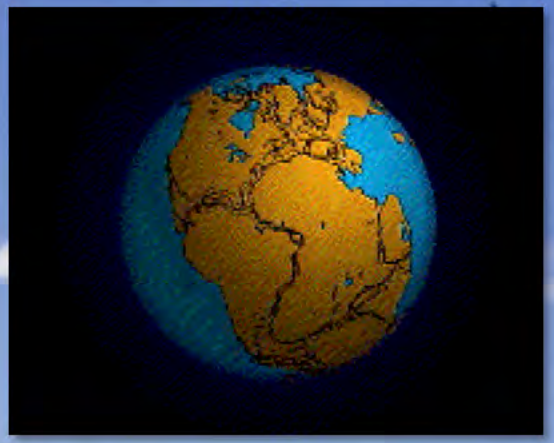
- Get an overview about production, quality, sizes,
  availability…

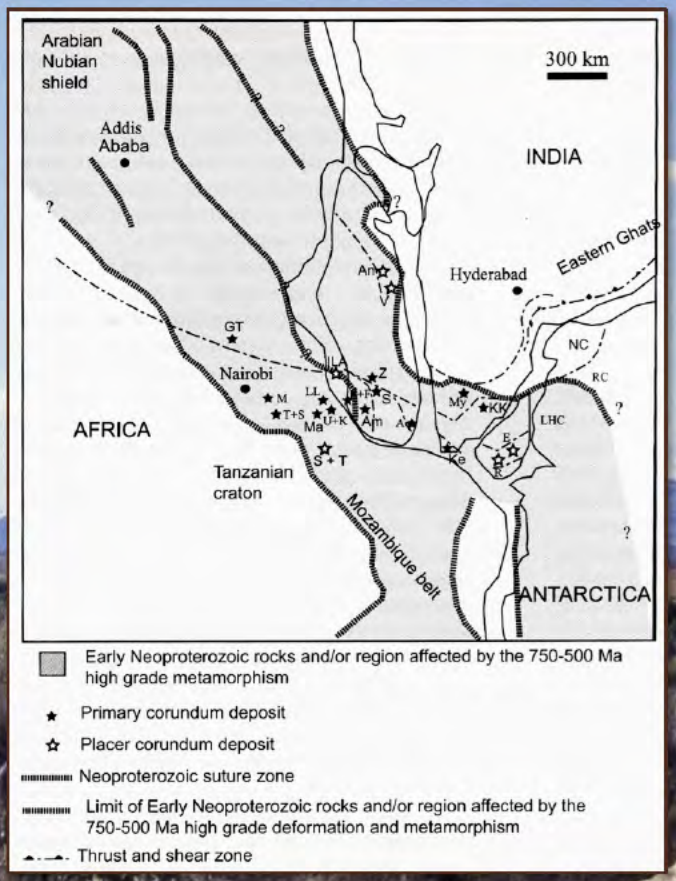
- Establish a catalogue of characteristic properties and
  internal features.

- 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





Guiliani et al. 2007

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.

The Challenge to Determine the Origin of Gems

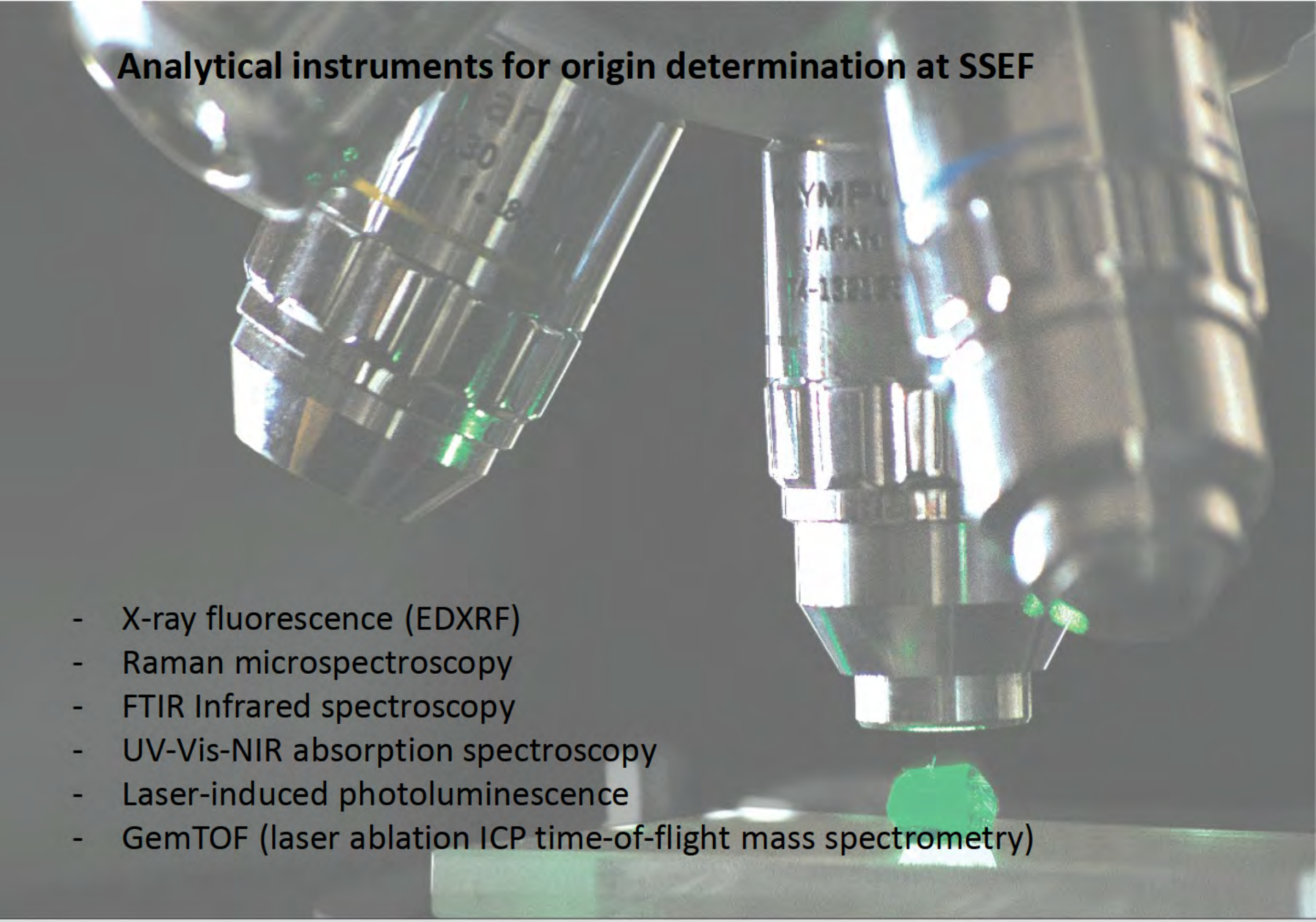
Formation of rubies in marbles

Mogok, 2016

SSEF


Ruby testing at SSEF

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)

Scarlet Drop
(13.95 ct)

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)

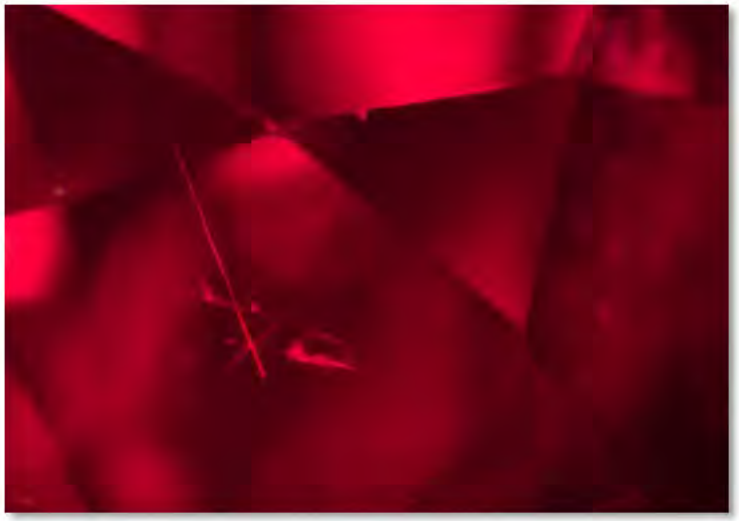
Rhino Ruby
(22.04 ct)

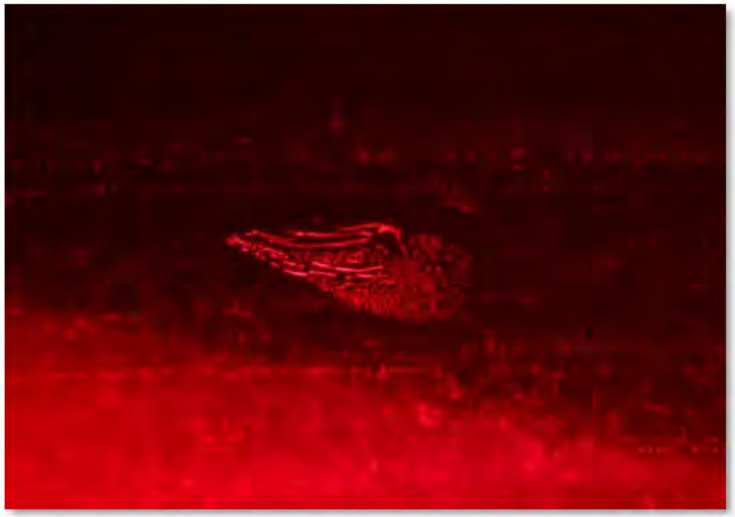
Detection of „Low-Temperature“ Heated Mozambique Rubies

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

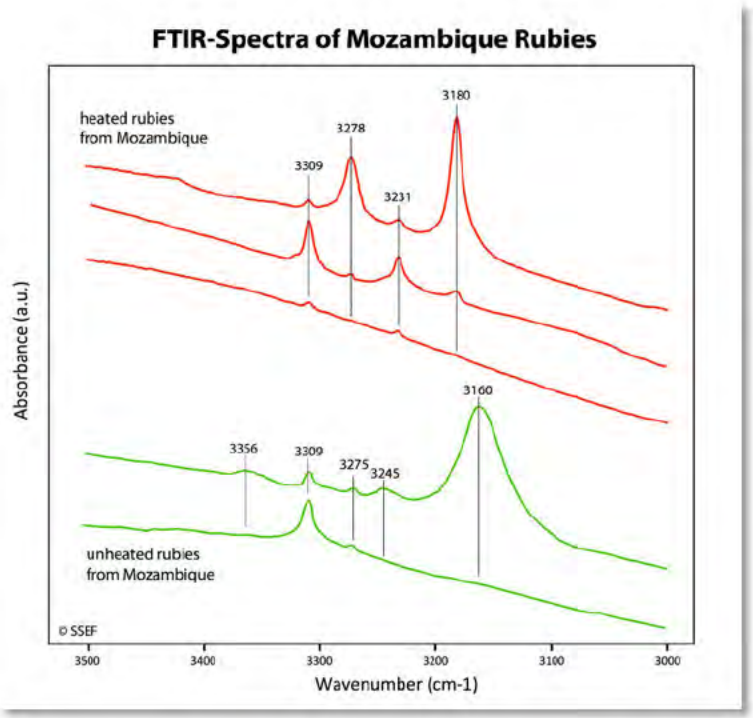




Characteristic microscopic features indicating a heat treatment such as a small disc-like expansion fissure (above) and a tiny heat-induced fissure at the surface (below) in heat treated Mozambique rubies.

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



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

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.

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PRESS RELEASE

FOR IMMEDIATE RELEASE
CONTACT: Dr. Michael S. Krzemnicki FGA
gemlab@ssef.ch

New research by SSEF studies methods for detecting low-temperature heated rubies from Mozambique

BASEL, SWITZERLAND · SEPTEMBER 12, 2018 – Since their discovery in early 2009, the ruby deposits near Montepuez in Mozambique have produced an impressive number of exceptional-quality stones, including iconic unheated gems such as the Rhino Ruby (22.04 cts), the Scarlet Drop (15.95 cts) and the Eyes of the Dragon (a pair of rubies weighing 11.26 cts and 10.70 cts), all of which were analysed by the Swiss Gemmological Institute SSEF. But from the very beginning, there has been evidence in the market of lower-quality rubies from Mozambique that have been heated with or without a flux (borax), resulting in healed fissures with residue, and in some cases heavily-fractured material that has been lead-glass filled.

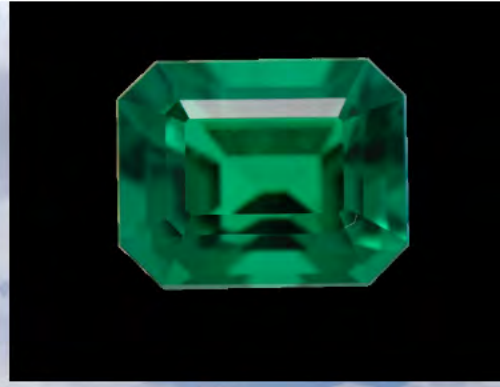
In more recent years, an increasing number of rubies from Mozambique have come onto the market, after having undergone so-called "low-temperature heating" (below 1000 °C). Presumably, the aim of this treatment is to enhance the colour slightly, by reducing subtle purplish zones which are sometimes present in rubies from this location (Figure 1).

Figure 1: Slightly purplish zone in ruby from Mozambique. Photo: M.S. Krzemnicki, SSEF

SSEF Press Release Sept 2018
see www.ssef.ch

Emeralds from Afghanistan

Panjsheer Valley



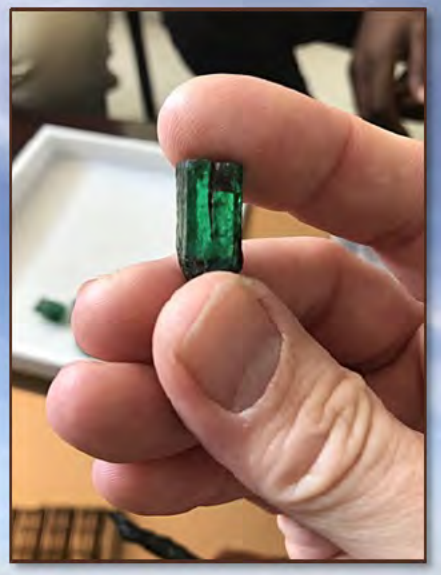
Emeralds from a new „pocket“ in Panjeer valley, Afghanistan

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

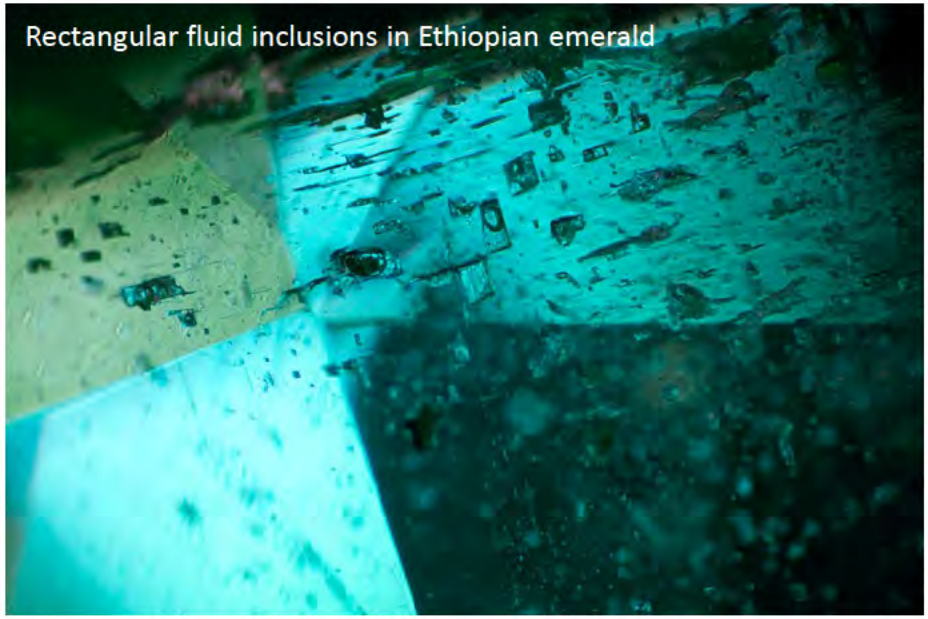


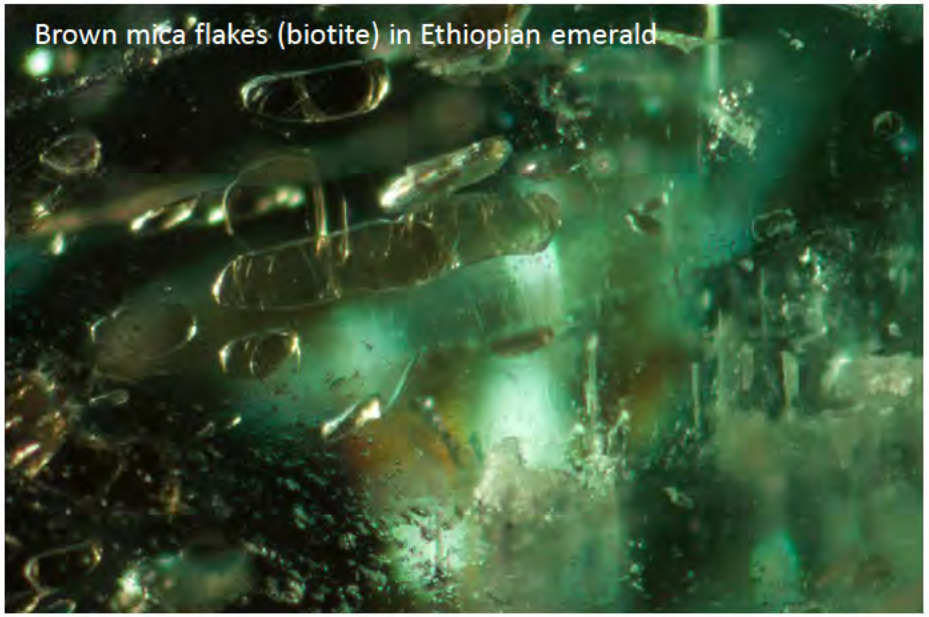
Photos © S. Hänsel, SSEF

Emeralds from Shakiso in southern Ethiopia

Newly discovered in November 2016

Emeralds from Shakiso in southern Ethiopia



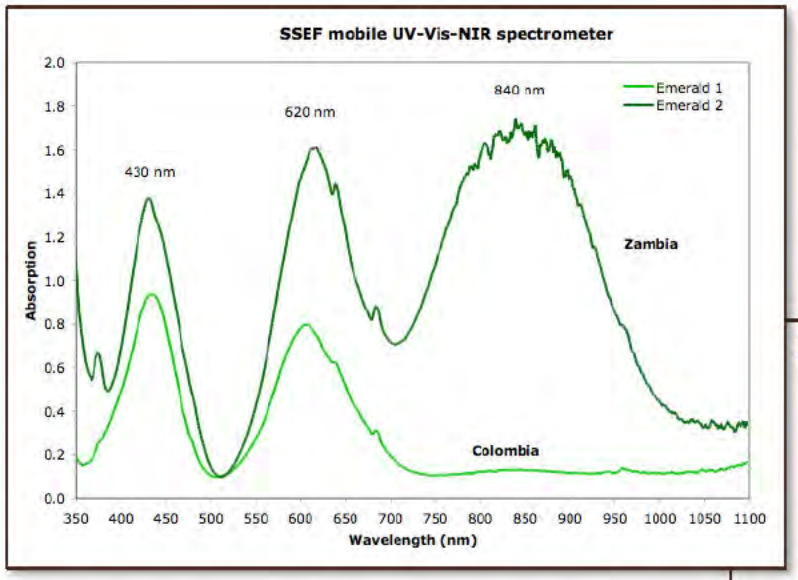


This new material from Ethiopia can be easily separated by microscope from emeralds originating from the classic mines in Colombia.

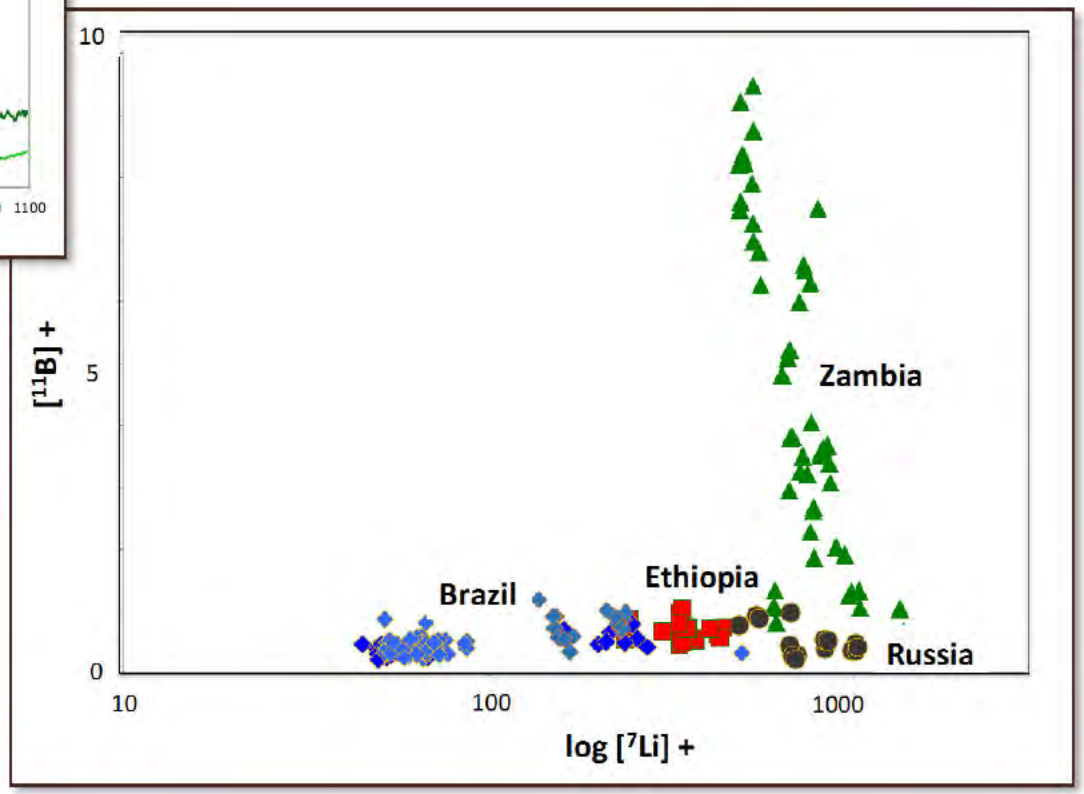
But is in many aspects - such as formation, properties and inclusions - very similar to emeralds from Zambia and therefore very difficult/impossible to separate from Zambian material just using the microscope.

Advanced instrumentation is necessary !

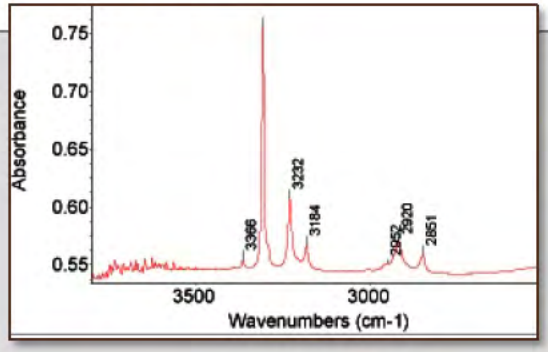
Emeralds from Shakiso in southern Ethiopia

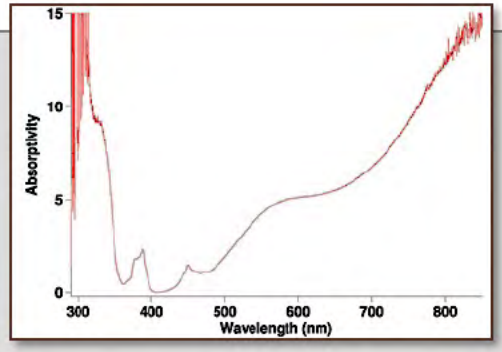


UV-Vis-NIR absorption spectrum and GemTOF trace element data plot to separate Ethiopian emeralds from Colombian emeralds (very different formation) and from Zambian and other biotite-schist related emerald deposits.



Sapphires from northern Ethiopia



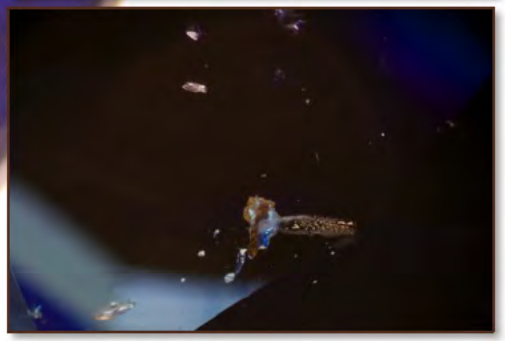


Ethiopian sapphires show features typical for sapphires from basaltic origin.

Recently in the spotlight

…and from Madagascar

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

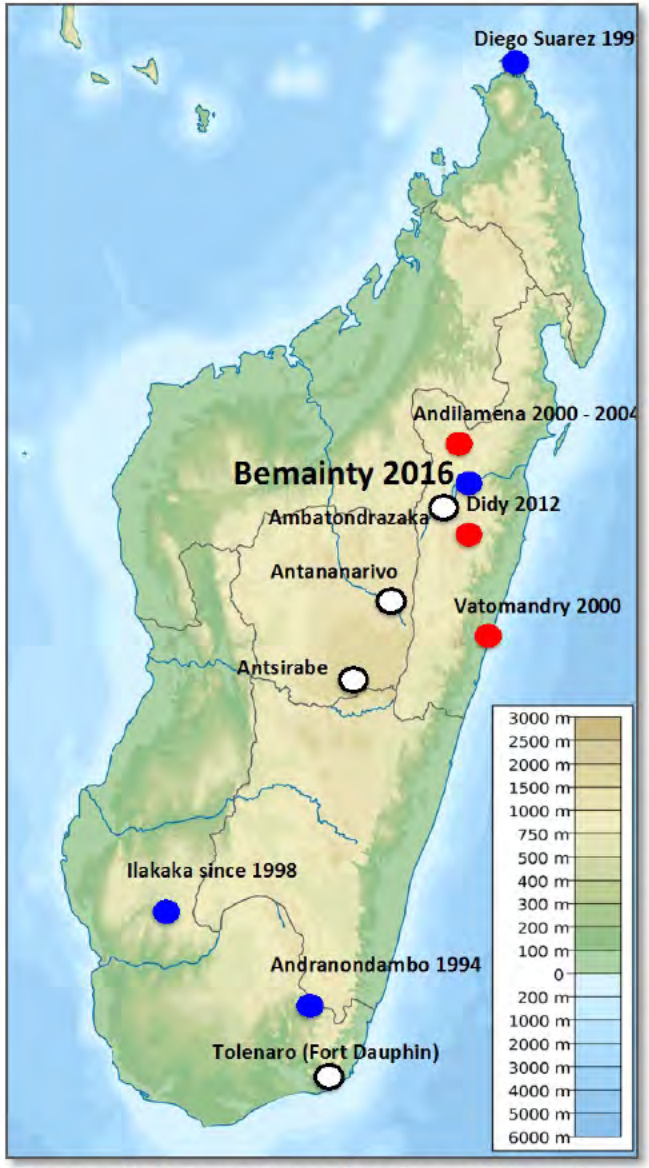


Recently in the spotlight

…and from Madagascar

New deposit discovered in October 2016 at **Bemainty**, near the small town **Ambatondrazaka**, Madagascar.

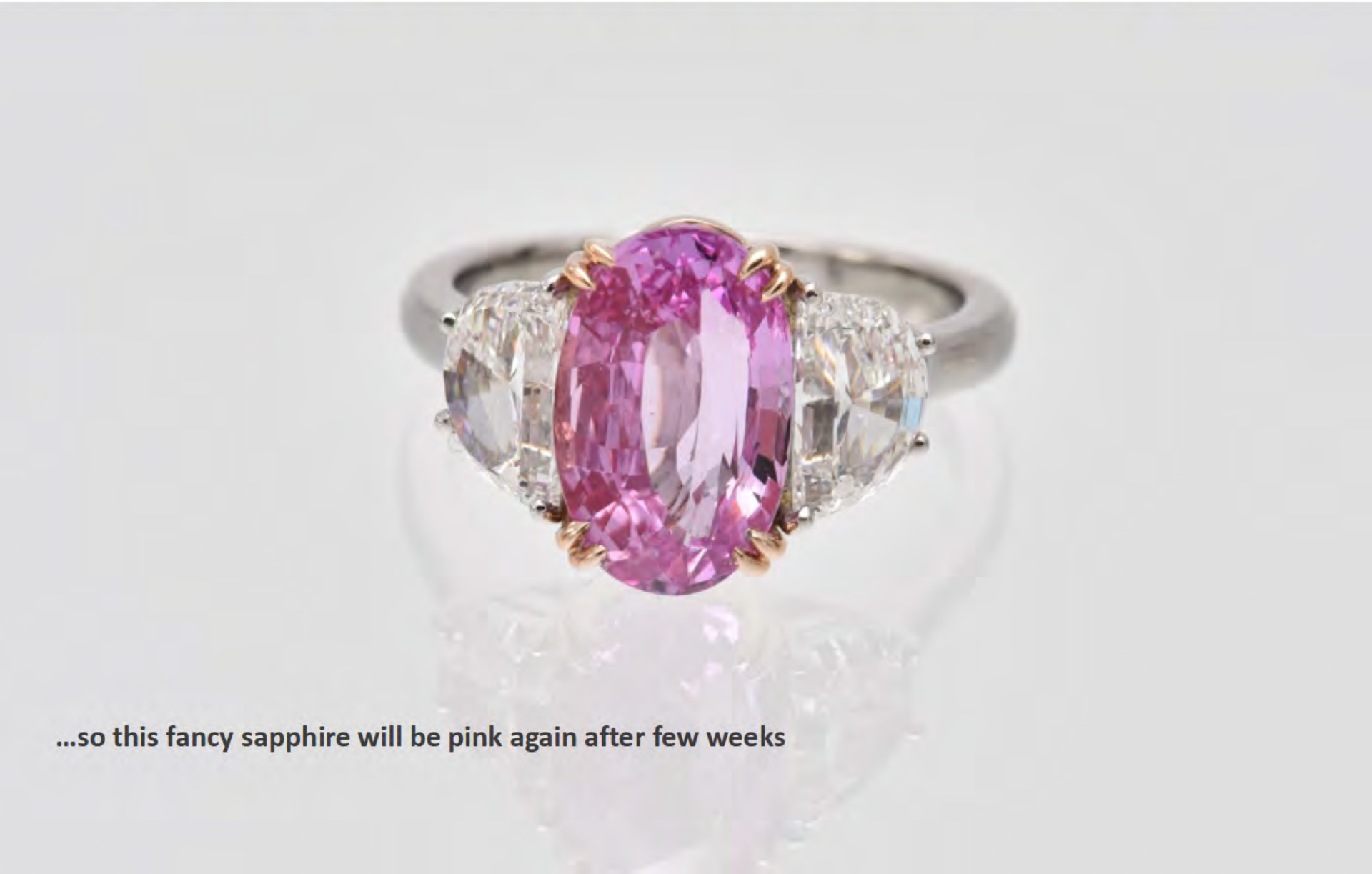
Mostly sapphires, but also fancy coloured varieties.



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

Recently in the spotlight

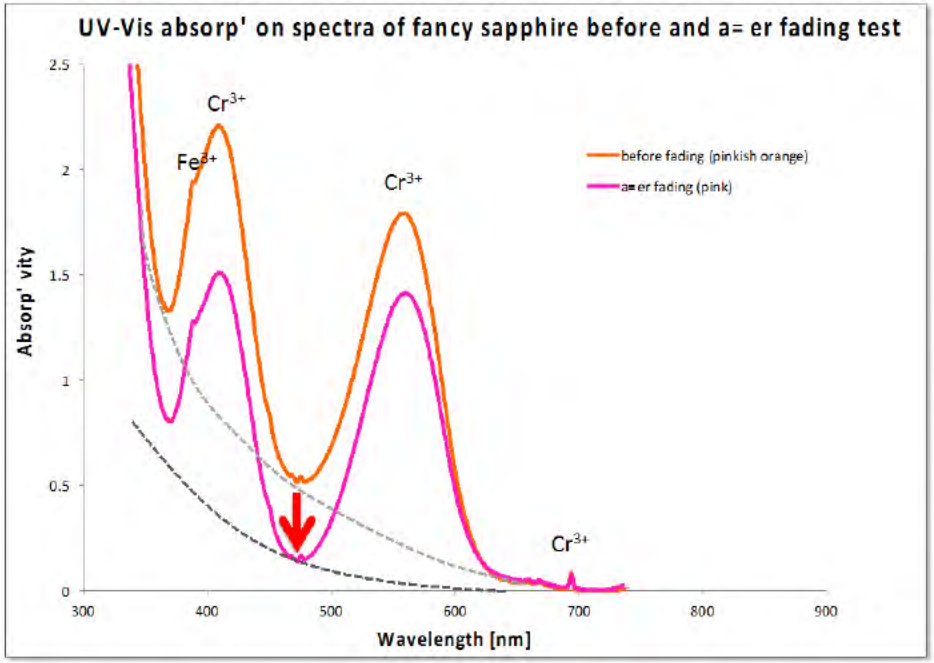
Fancy Sapphires with unstable Padparadscha-like colour



...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

GEMMOLOGY |

Sapphires from a New Deposit at Bemainty near Ambatondrazaka in Madagascar

By

UV-Vis spectra of Sapphires from Ambatondrazaka

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. Krzemnicki, 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 (Krzemnicki 2017 *in SSEF Facette* www.ssef.ch/research_publications/facette/ and upcoming *Journal of Gemmology*, Perkins 2016, Perkins & Pardieu 2016, Pardieu 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 and size (left 30 ct, right 13 ct) of 'Kashmir-like' sapphires from Bemainty near Ambatondrazaka in Madagascar. Photo: SSEF

The velvety blue of Kashmir sapphires


Photo © H.A. Hänni, SSEF


The Maharaja of Jammu and Kashmir, circa 1900
www.kashmirphotos.org/history.html

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

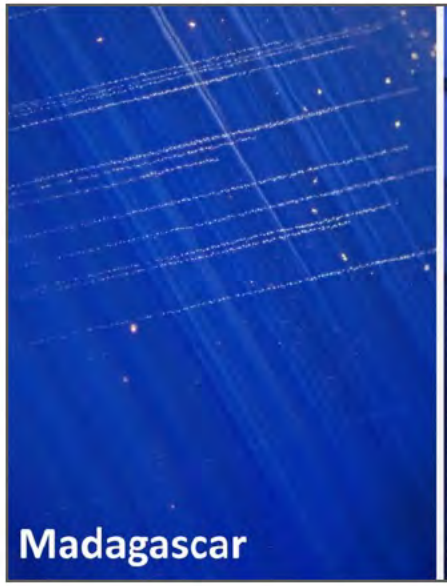
As a result, these stones often show a highly appreciated **velvety** blue colour.

The Kashmir - Madagascar challenge !

The Kashmir – Madagascar Challenge

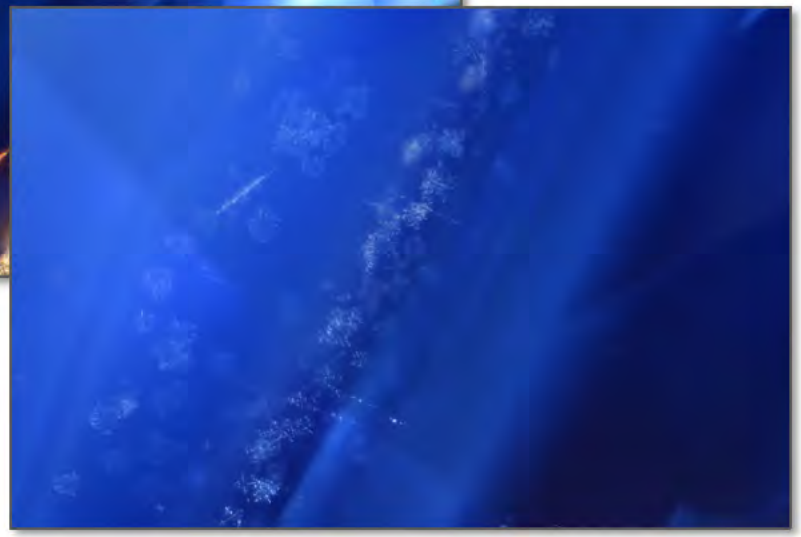
The newly discovered sapphires from Bemainty show a milkyness, resulting in an attractive velvety blue colour similar to Kashmir sapphires.

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

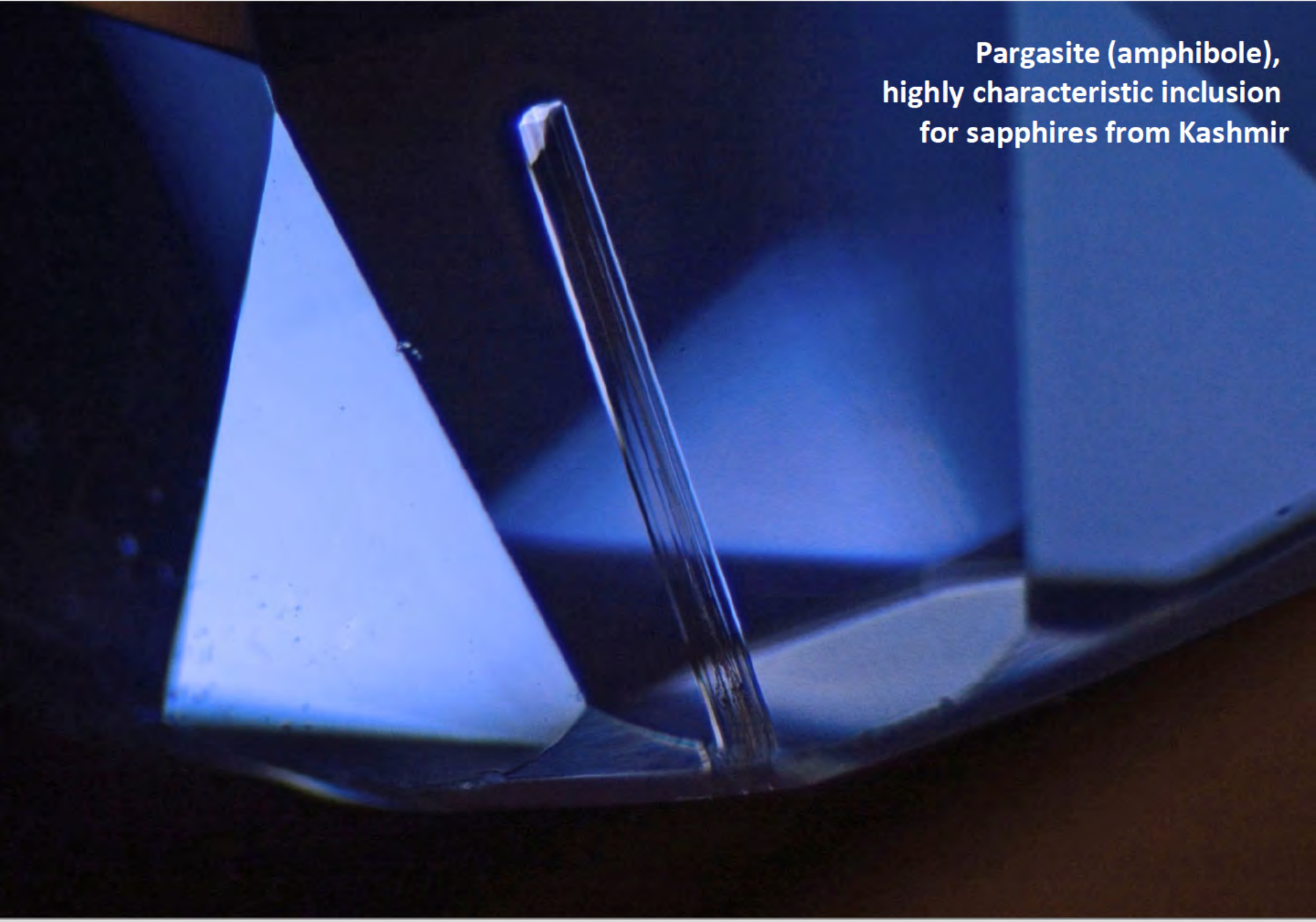


Distinct colour zonation in sapphire from new deposit at Bemainty (Madagascar)

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

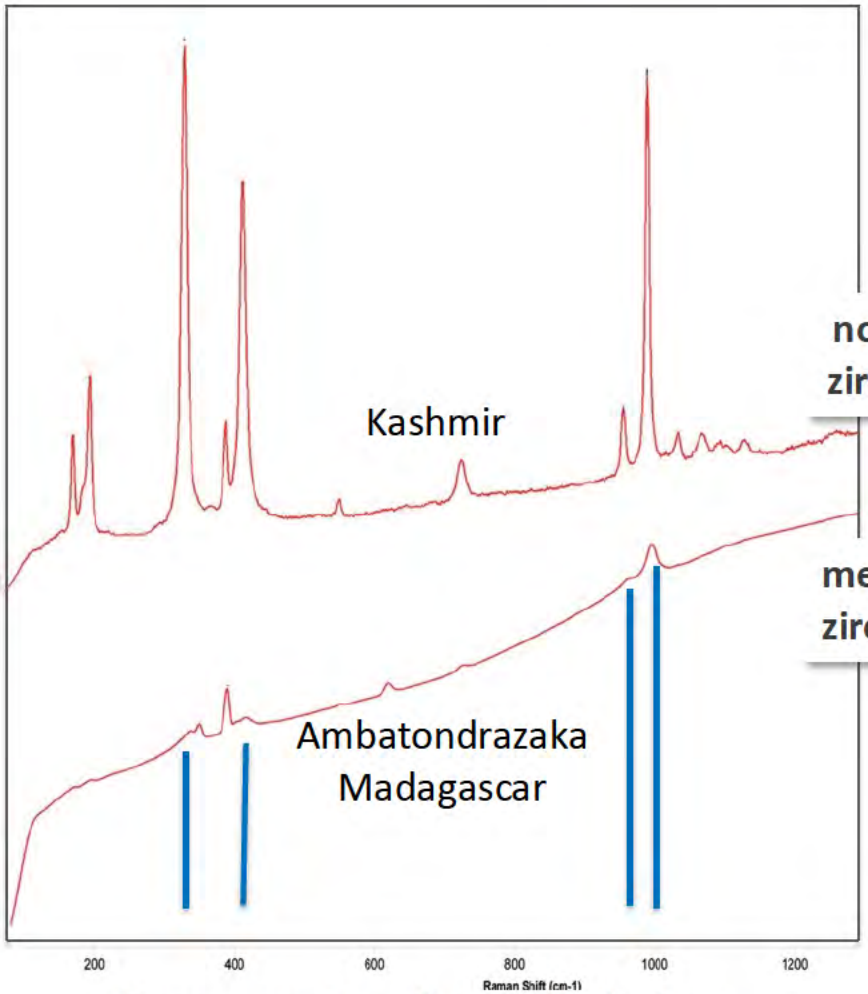
Kashmir

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



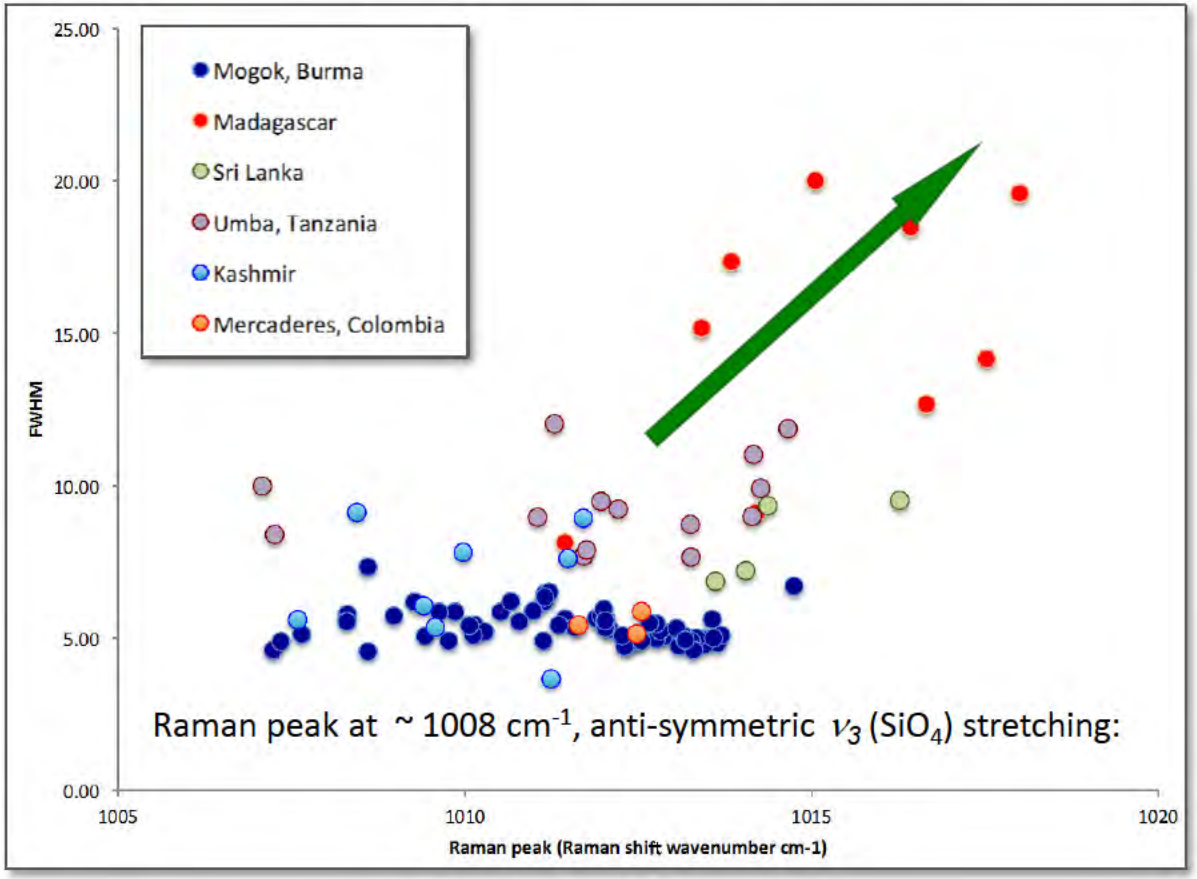
non-metamict zircon inclusion

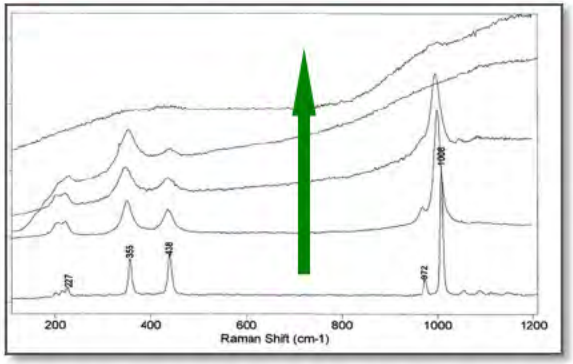
metamict zircon inclusion

Raman spectra of zircon inclusions

The Kashmir – Madagascar Challenge

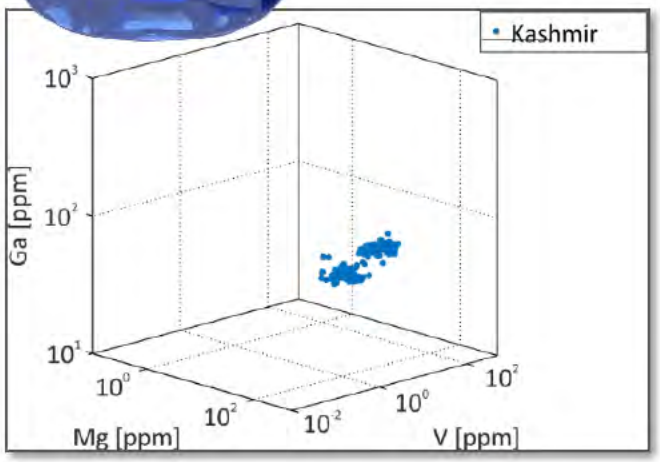
Analysis of Raman spectra (position and peak width of 1008 cm^{-1} peak) of zircon inclusions of corundum (ruby/sapphire) from different origins.

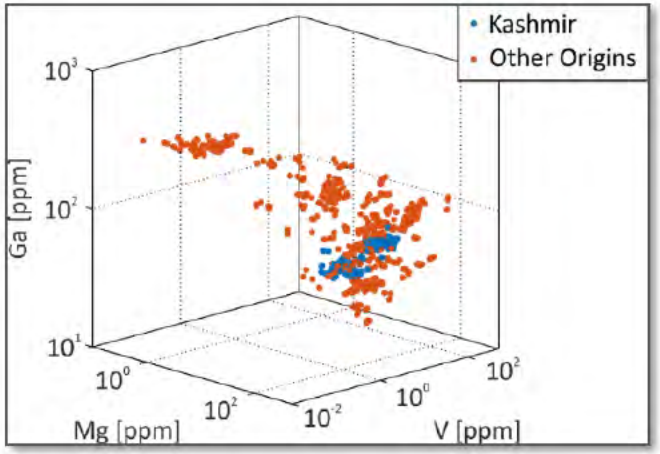




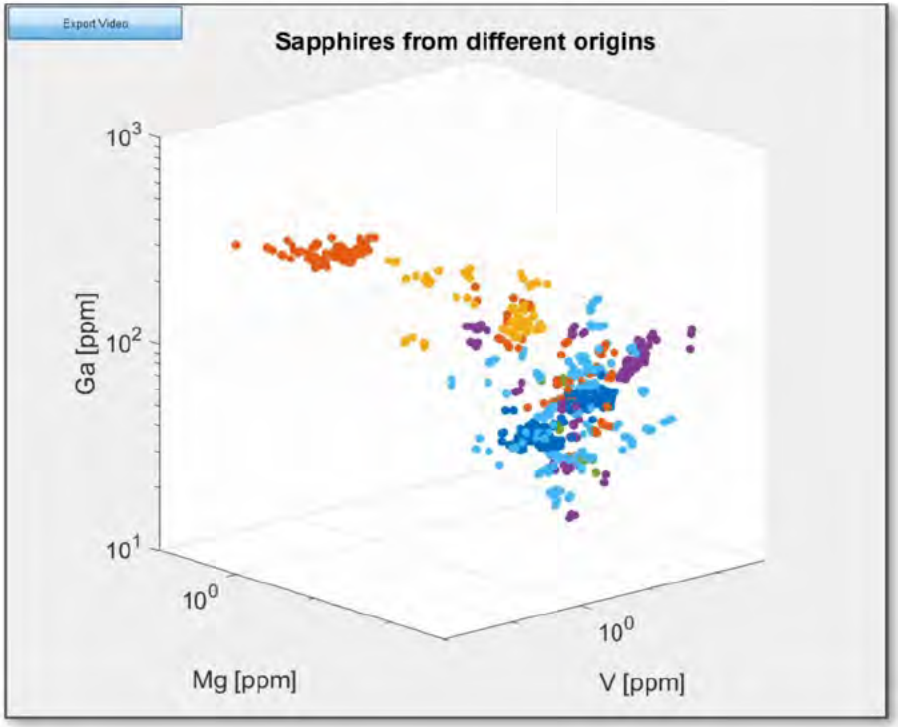
increase in metamictisation

The Kashmir – Madagascar Challenge



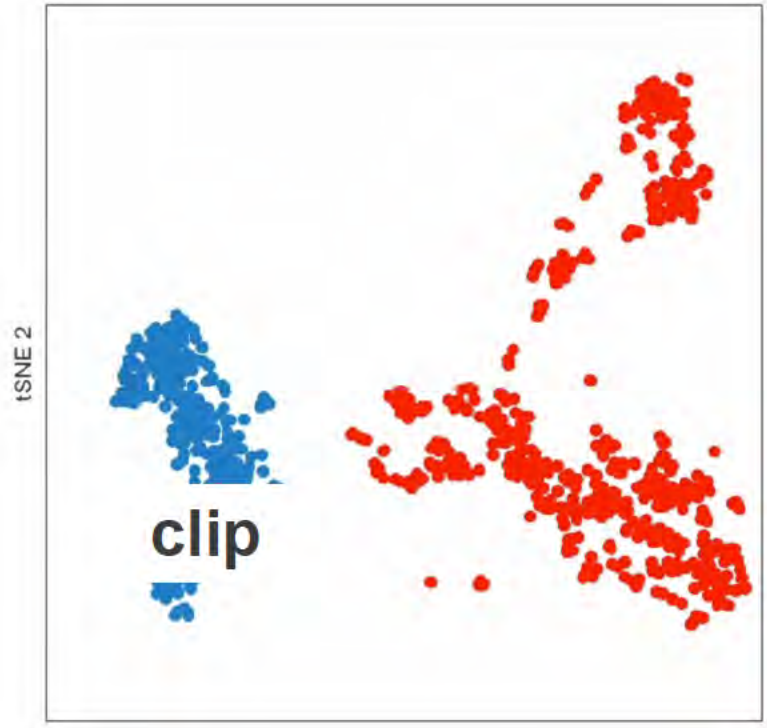


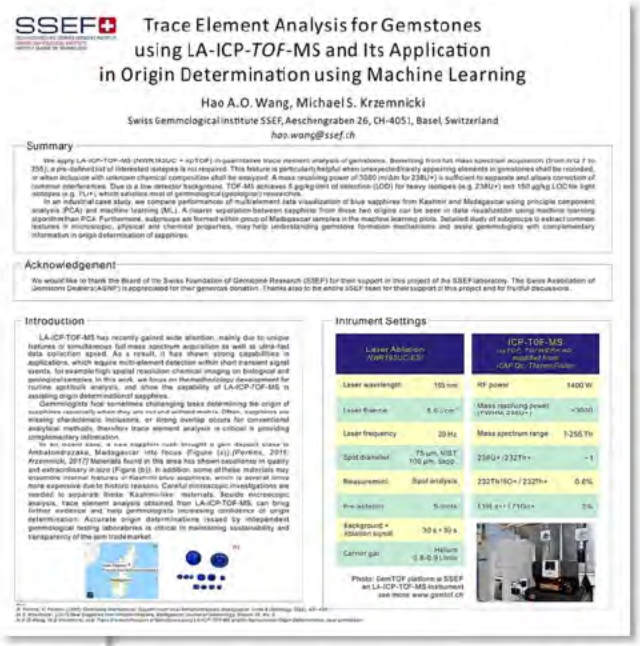
GemTOF (Laser Ablation ICP Time-of-Flight Mass Spectrometry) is a very powerful tool to analyse trace elements of gemstones, thus supporting origin determination at SSEF.



Latest research at SSEF

The Kashmir – Madagascar Challenge





SSEF Trace Element Analysis for Gemstones using LA-ICP-*TOF*-MS and Its Application in Origin Determination using Machine Learning

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Summary

Acknowledgement

Introduction

Instrument Settings

WinterPlasma Conference, January 2018

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