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Scottish Gemmological Association - Conference,
Saturday 3 May 2014

The quest for "Kashmir" sapphires and "Burma" rubies

Origin determination of gemstones: Possibilities, Challenges and limitations

Dr. Michael S. Krzemnicki, Swiss Gemmological Institute SSEF

The *Star of Kashmir*
Sapphire from Kashmir of approx. 20 ct,
Geneva May 2013, 3.5 mio US$
SSEF Test Report No. 66221

Photo © Christie's

Burmese ruby

A superb ruby of 6.04 ct set in a ring with diamonds by Etcetera.

Sold for a world auction record price of US$ 551'000 per carat (Christie's Hong Kong, May 2012).

SSEF report 59356
& Appendix.

A number of sources of coloured stones are known since historic times and their gems have been treasured over centuries for their beauty and rarity.

The relevance of the origin of a gemstone

- emotion
- connecting to history
- a label
- for investment

Bagan, Burma © P. Boegli, Flickr.com

Jose Boomsma: Tribute to Rothko -Blue

Rothko: untitled

Origin determination is always an expert opinion !

The origin determination of gemmological laboratories is always based on scientific analyses (e.g. trace element composition, absorption spectra, Raman microspectrometry etc.) and meticulous microscopic observations.

Thus it is possible that two different labs may issue a different origin for a given gemstone.

Origin determination:

Combining classical approaches with advanced scientific analytical methods

The origin of a gemstone on a report is always an opinion of experts, indicating its most probable geographic origin.

It describes stones which originate from a mining operation in that geographic area.

It is related to the geological setting characteristic for the origin (mining area).

The origin is expressed based on well-established criteria (e.g. inclusions, chemical composition...).

Challenges:
- New mining areas are discovered.

- The analytical methods get more and more sophisticated.

Origin determination at SSEF is relying on:

- scientifically and gemmologically highly educated staff

- sophisticated analytical instrumentation

- reference samples from different mines

- continuous research

- long established experience

Four steps of origin determination:

1) Observations and collection of analytical data

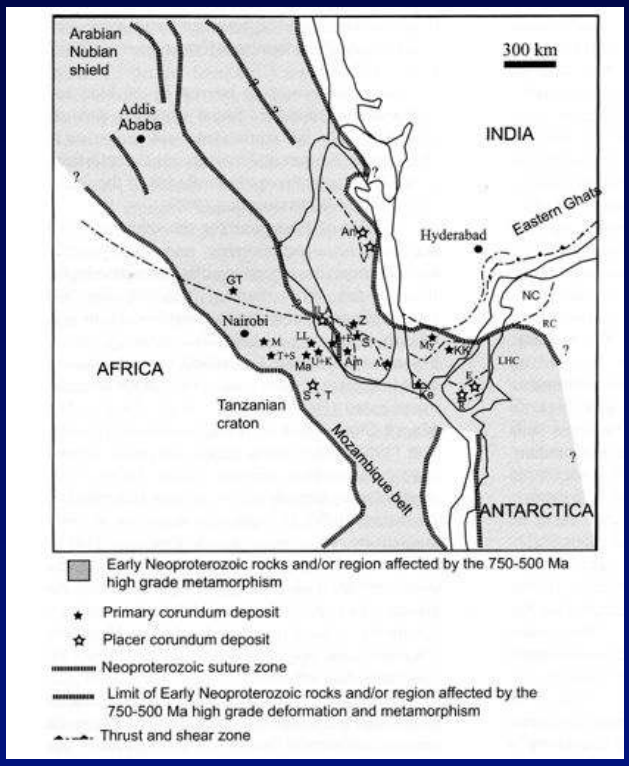
2) Interpretation of observations and data

3) Weighting of evidences and consistency check

4) Conclusion(s)

Important:
Independent assessment of a gemstone by second (third etc...) expert (gemmologist) and mutual discussion !!

Deposits connected to Pan-African tectonometamorphic events



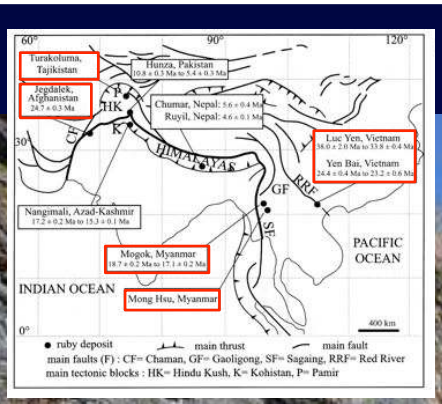
Distribution of corundum deposits connected to Pan-African tectono-metamorphic events (750-450 ma) by the collision of eastern and western Gondwana.

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

TRIASSIC
200 million years

marble-hosted deposits

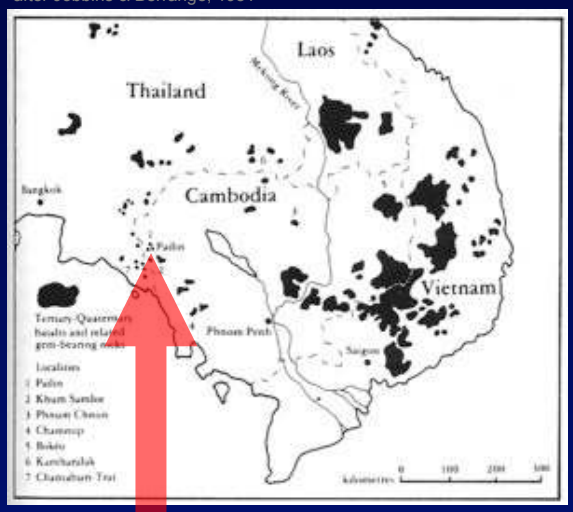
Distribution of marble-hosted ruby deposits along the Himalayan orogeny (45-5 ma) due to the collision between the Indian plate and Eurasia.



Dattaw mine : Mogok East

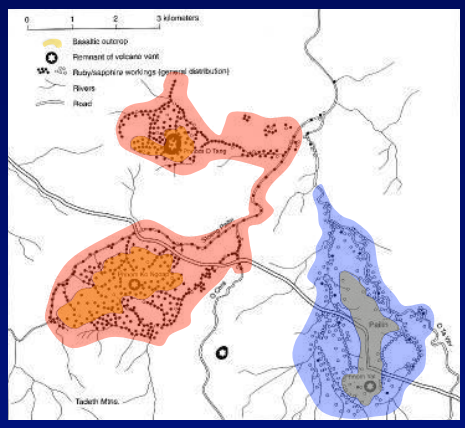
Corundum from alkali basalts

after Jobbins & Berrangé, 1981



Tertiary and quaternary basalts and related corundum deposits in South-East Asia.

Pailin



Jobbins & Berrangé, 1981

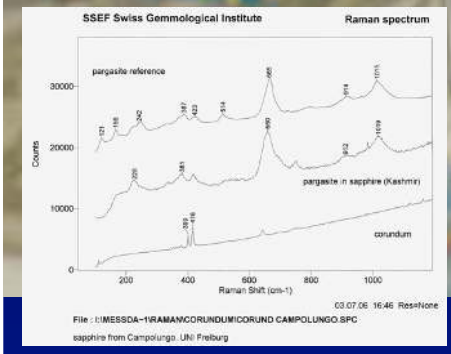
Analytical instruments used for origin determination at SSEF

- X-ray fluorescence (EDXRF)
- Raman Microspectrometry
- FTIR Infrared Spectrometry
- UV-Vis-NIR Spectrophotometer
- Photoluminescence

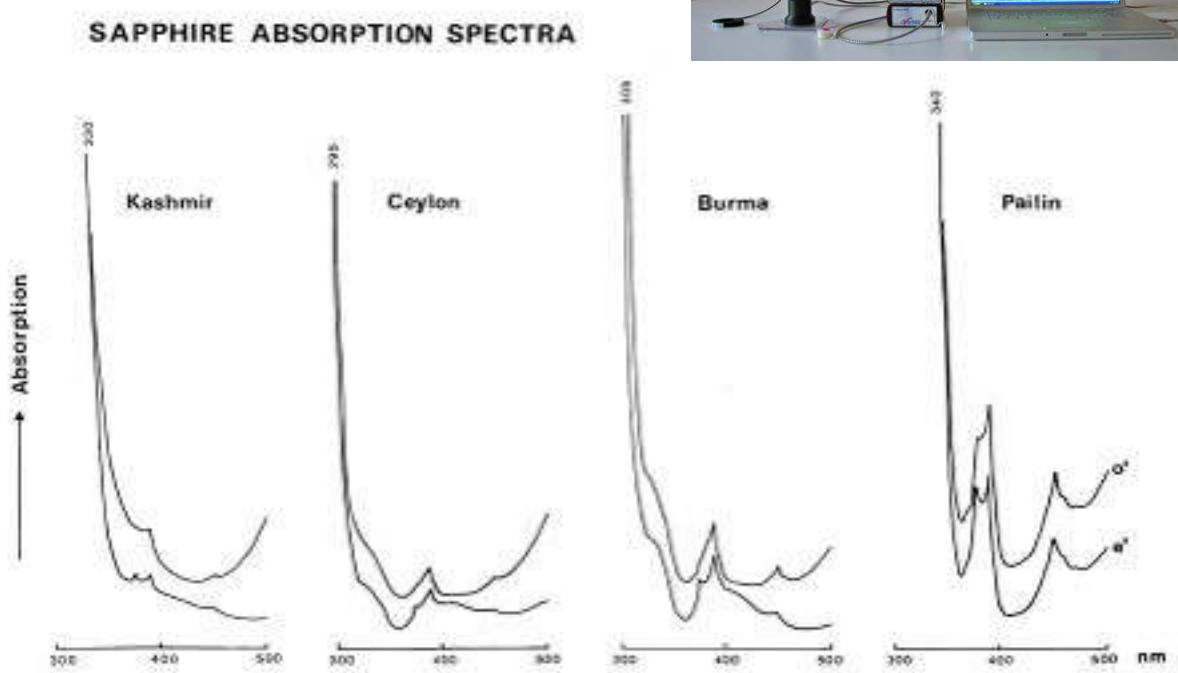
Eventually:

- LA-ICP-MS (laser ablation inductivey coupled plasma mass spectrometry)
- LIBS (laser induced breakdown spectroscopy)

Raman microspectrometry

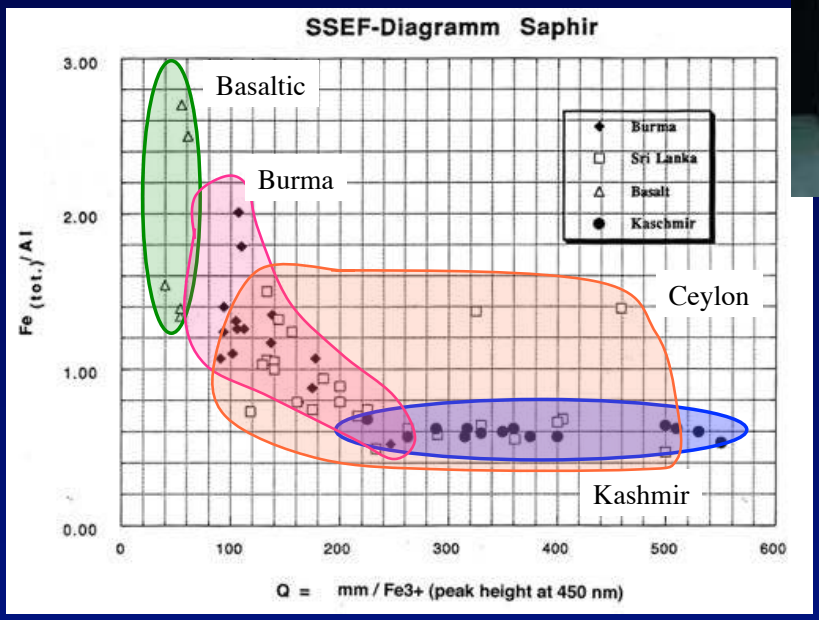


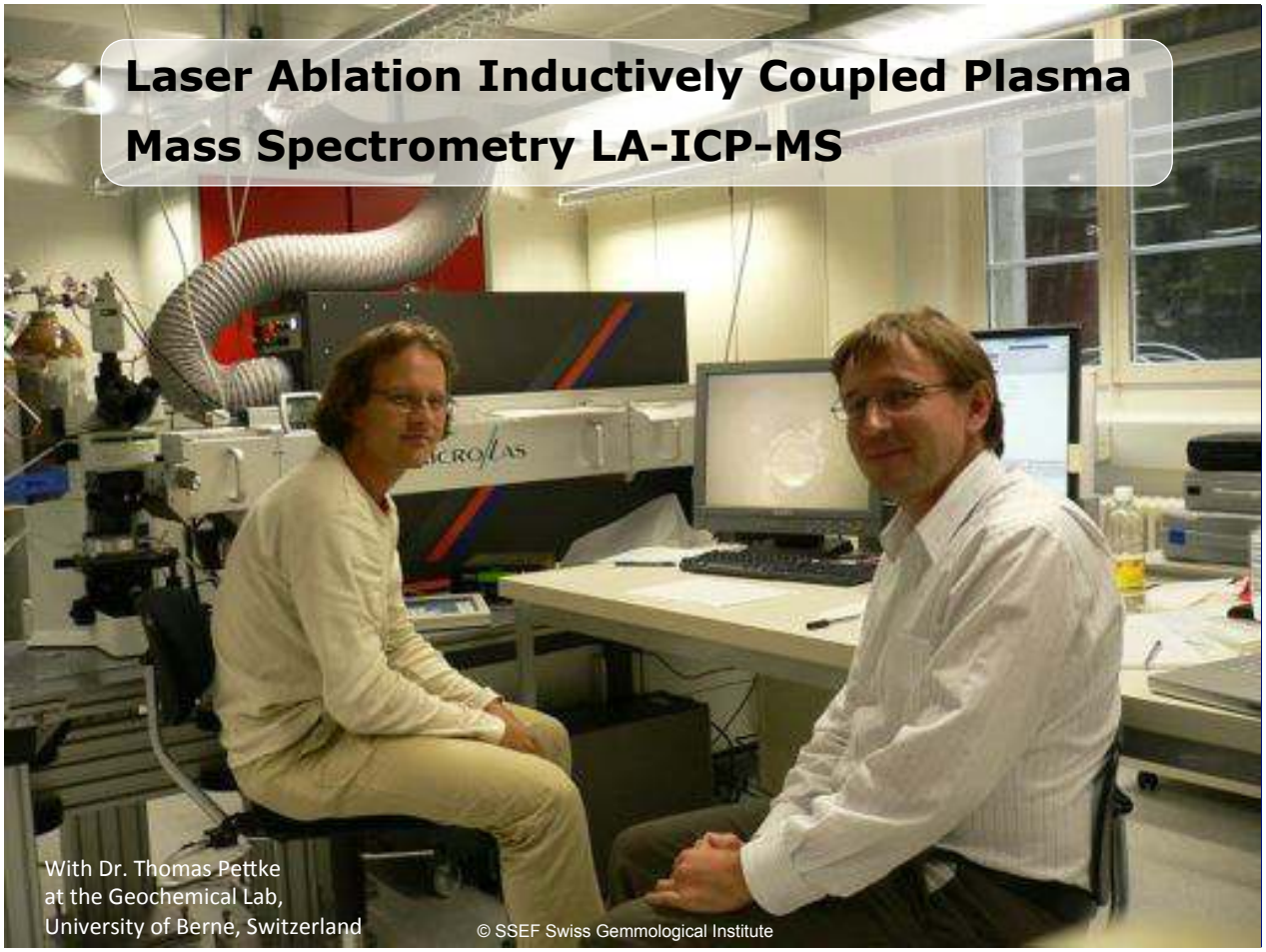
UV-Vis Spectrometry



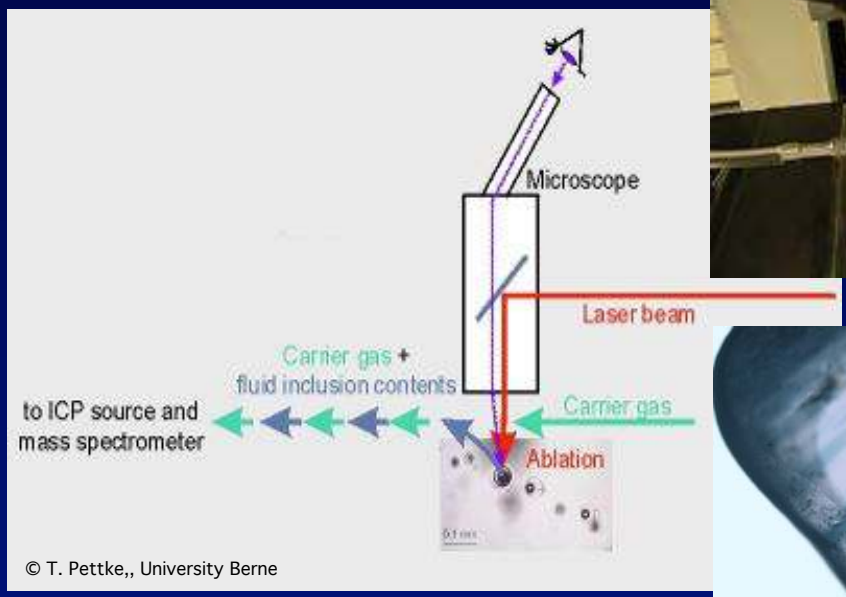
from H.A. Hänni, Journal of Gemmology 1994

Chemical data versus spectroscopic data

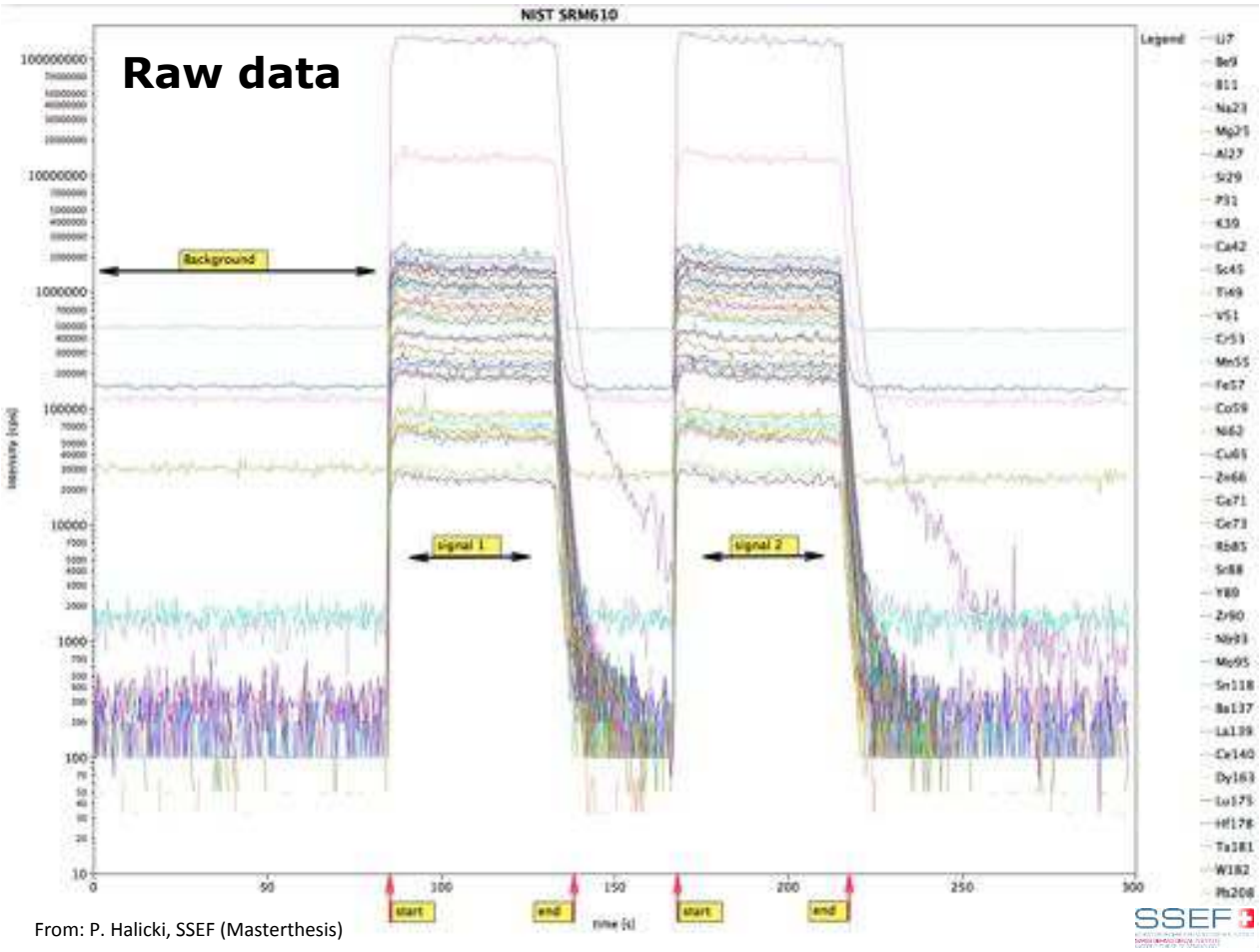




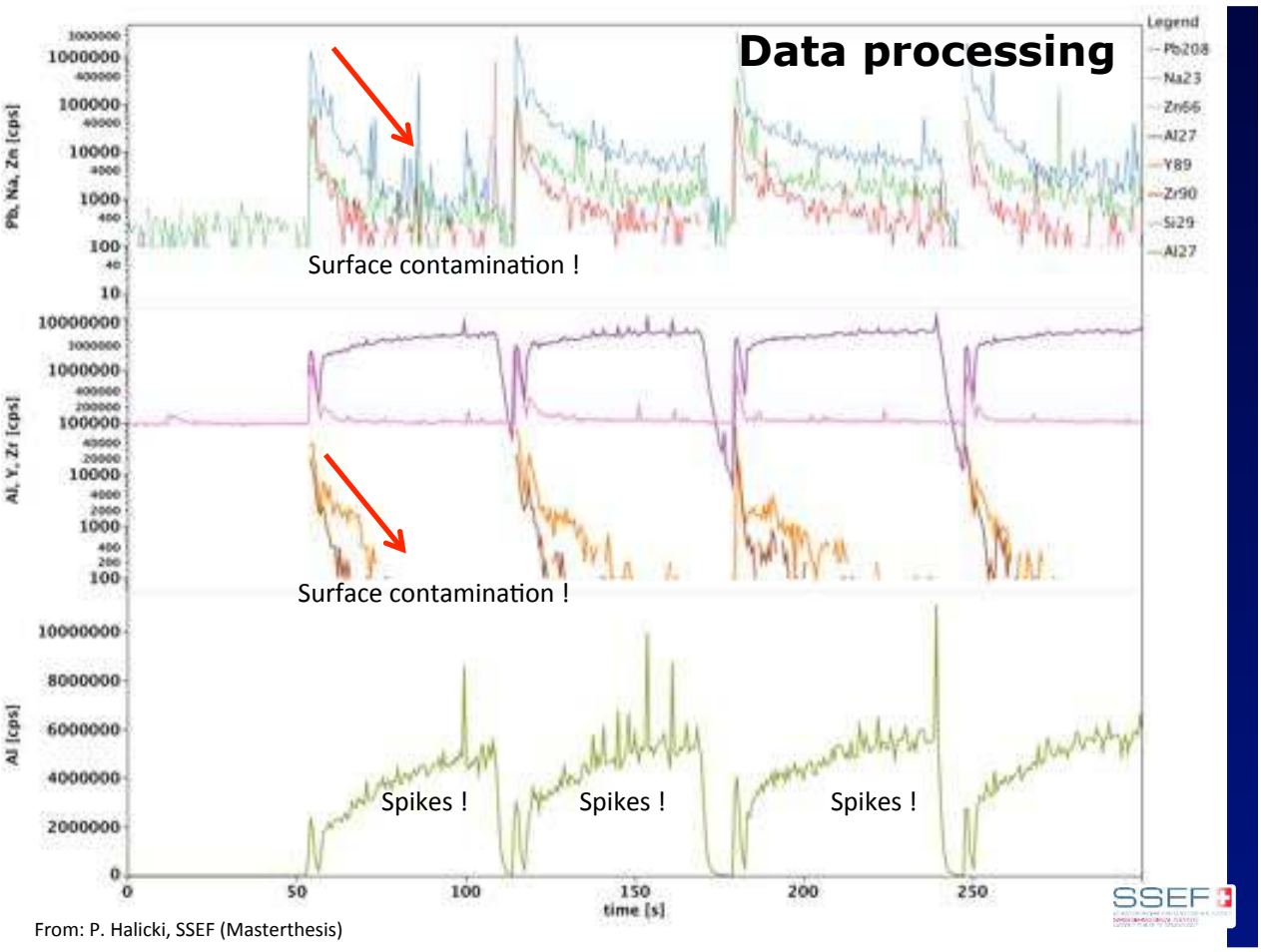
Laser ablation



Local heating and vaporization



From: P. Halicki, SSEF (Masterthesis)



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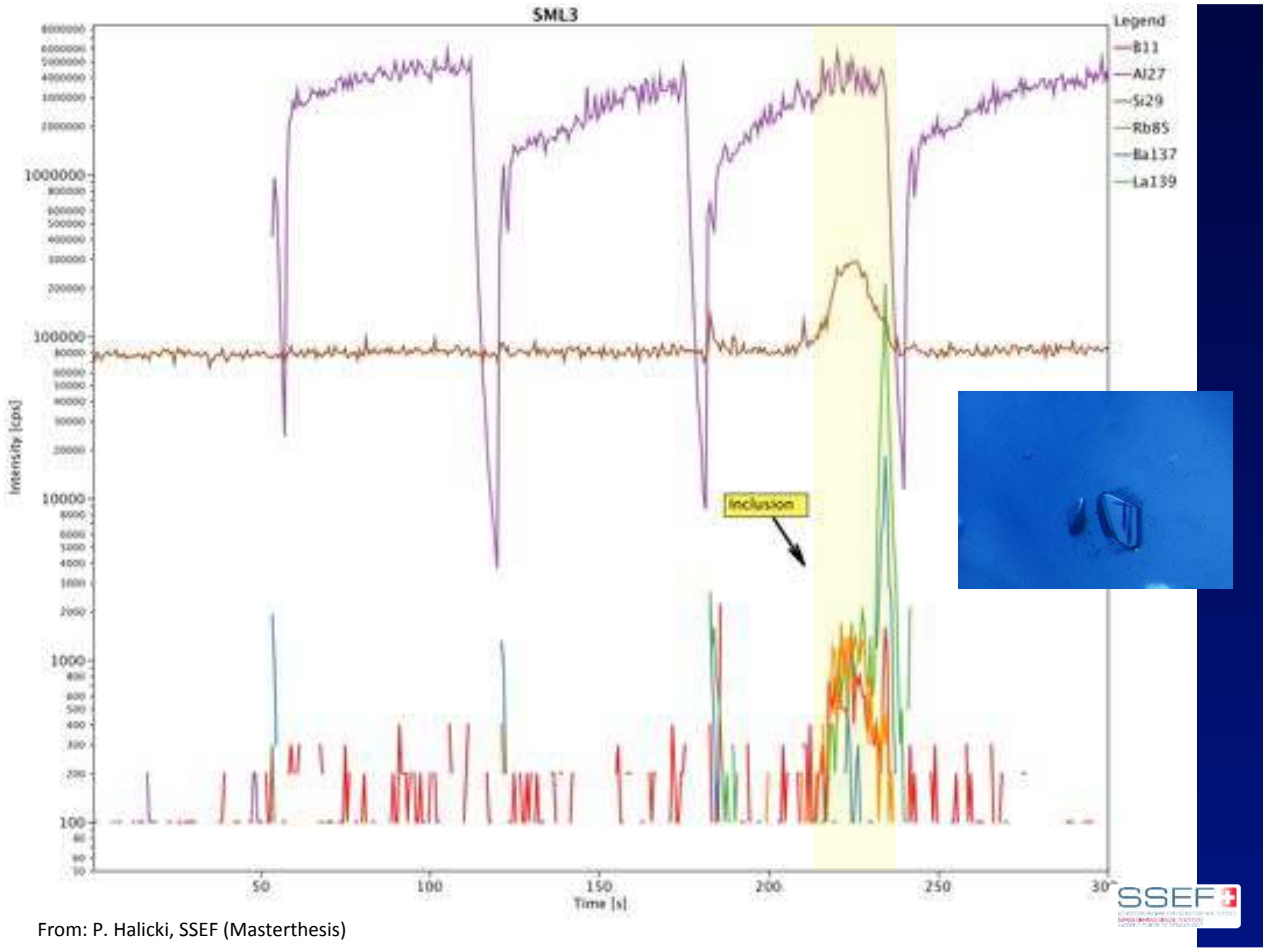

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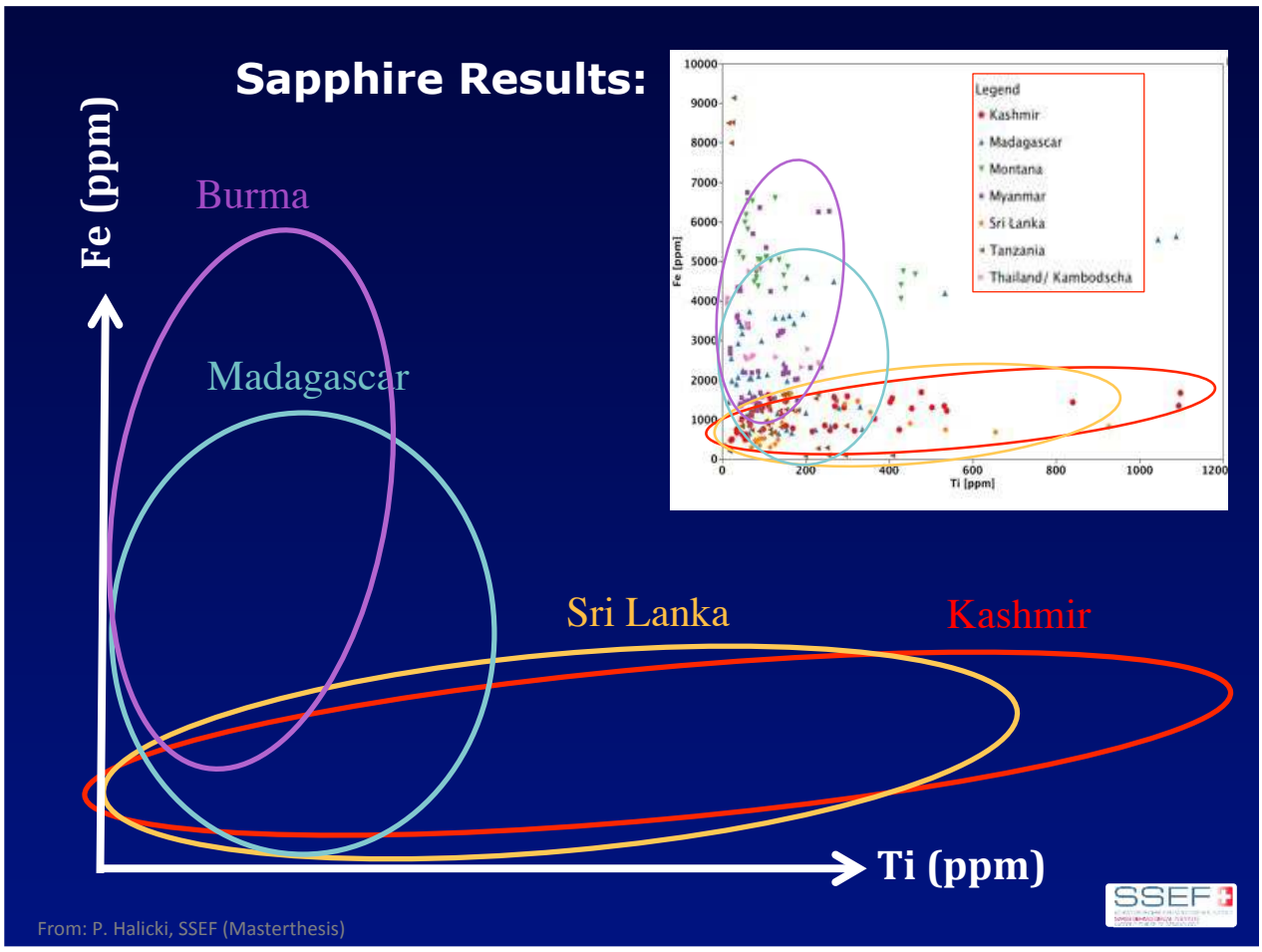
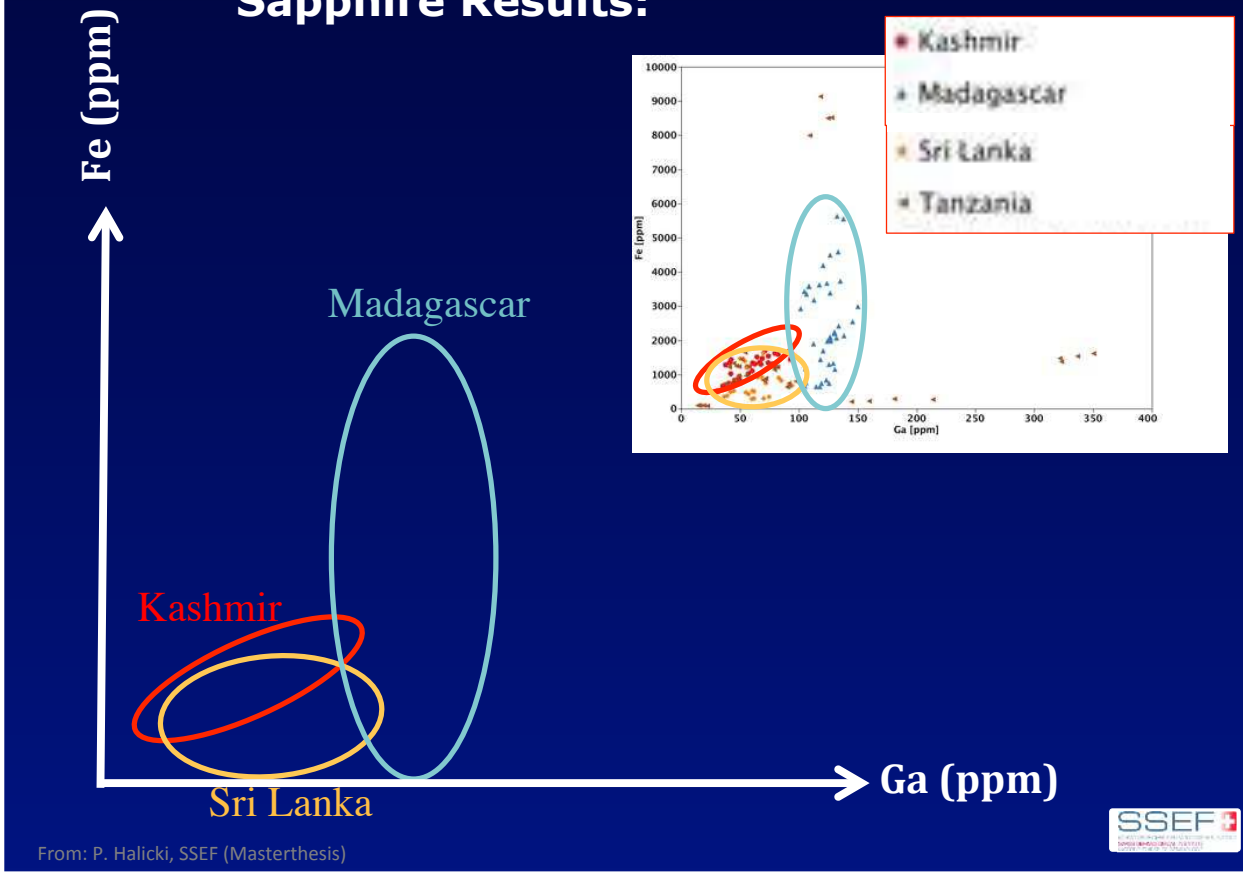


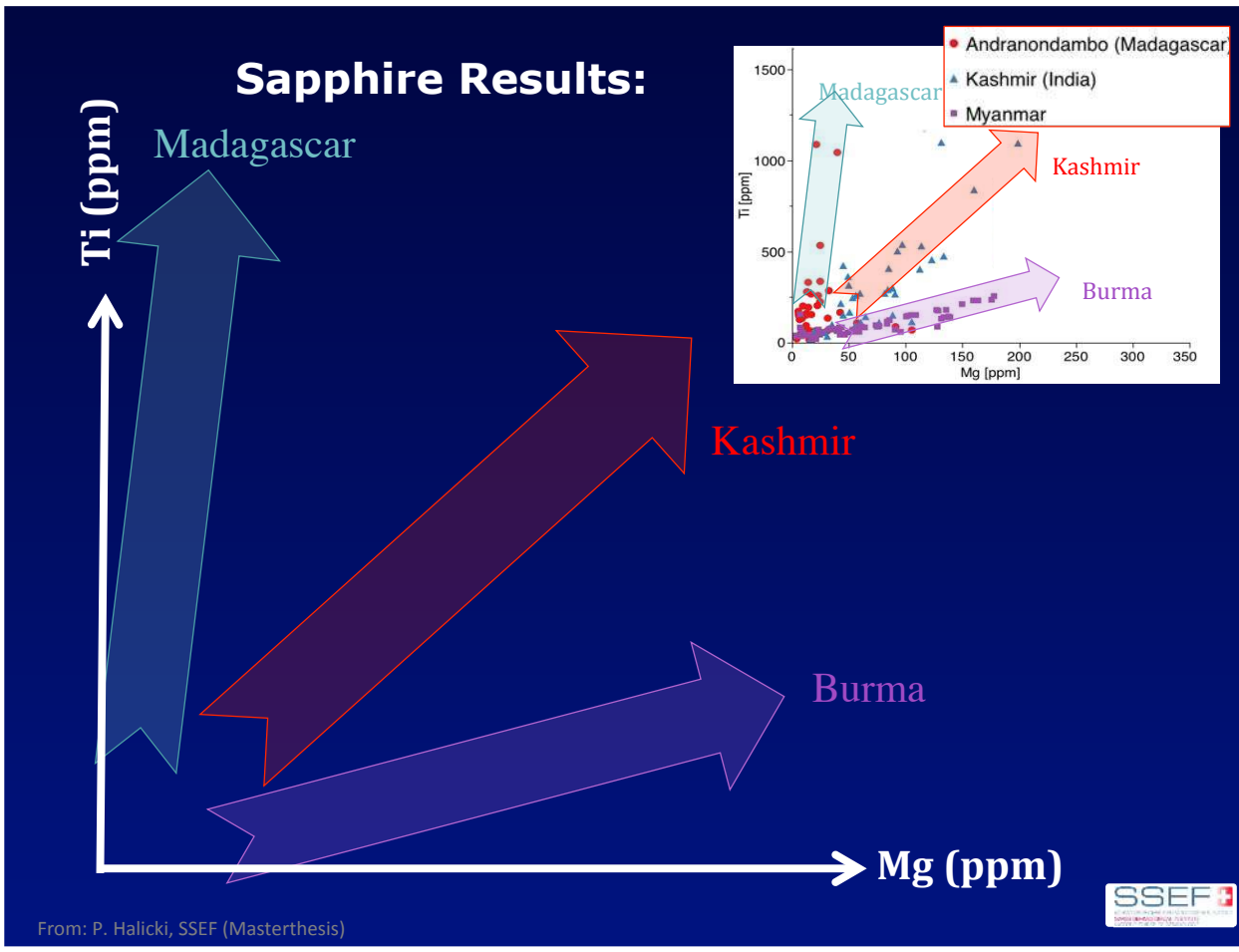
From: P. Halicki, SSEF (Masterthesis)

Sapphire Results:



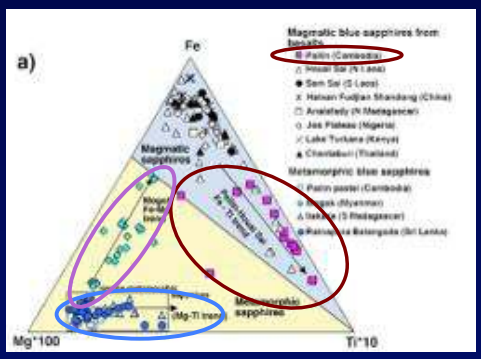
From: P. Halicki, SSEF (Masterthesis)

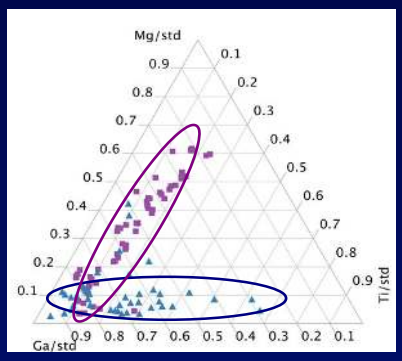
Sapphire Results:

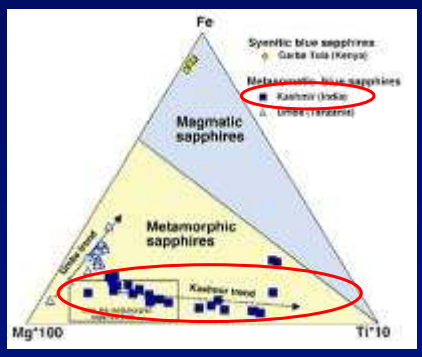


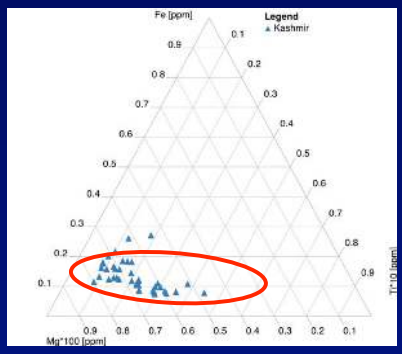
From: P. Halicki, SSEF (Masterthesis)

Possibilities & Limitations:









Trace element concentrations generally indicate origin „trends“, but are often not resulting in conclusive results.

From: P. Halicki, SSEF (Masterthesis)

The velvety blue of Kashmir sapphires

Photo © H.A. Hänni, SSEF

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

Characteristic inclusions in Kashmir sapphires

Zoning pattern
no rutile needles in Kashmir sapphires !

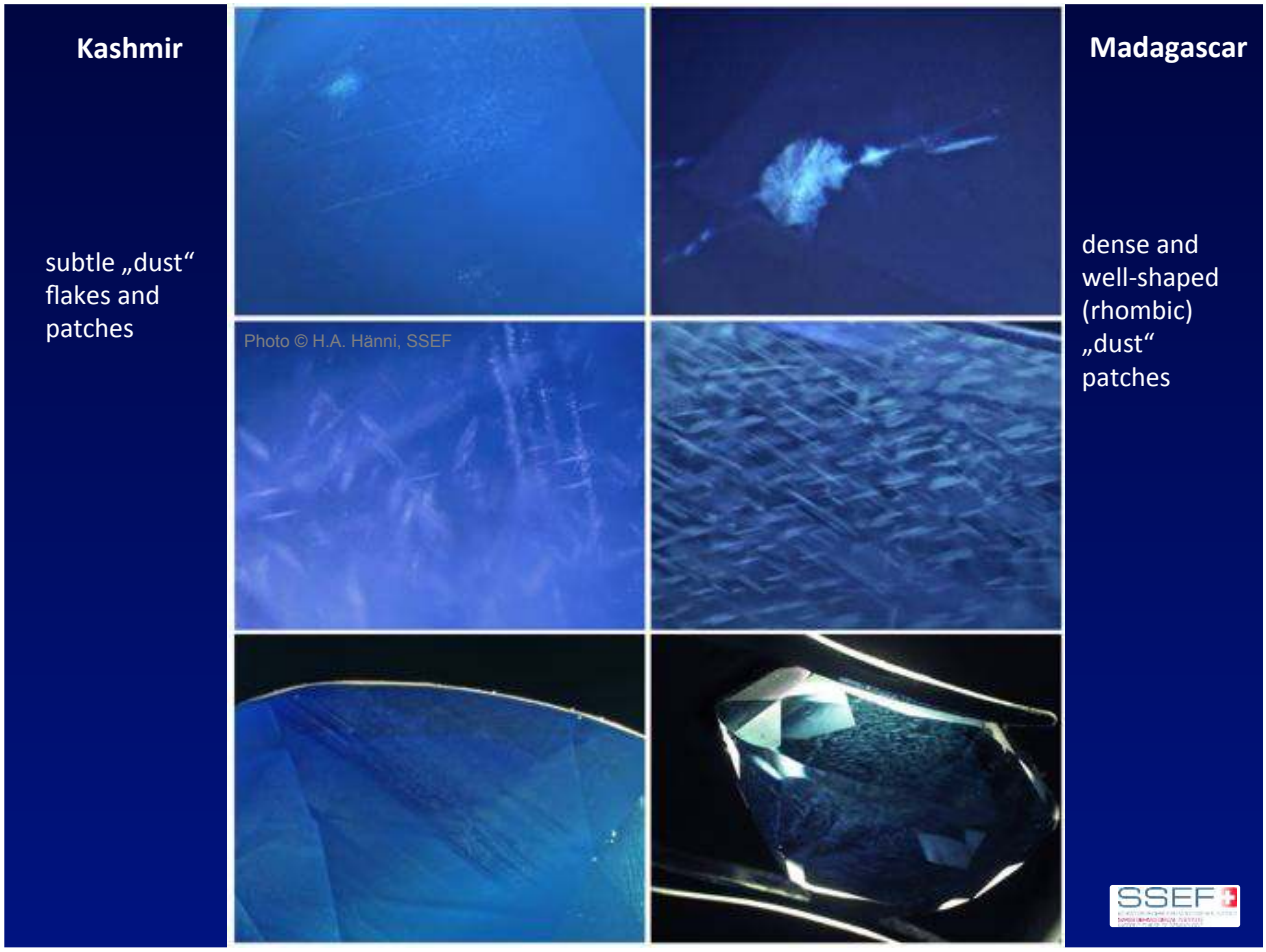
Photos: © H.A. Hänni, SSEF

Subtle „dust“ tracks

healed fissure with interrupted fluid tubes

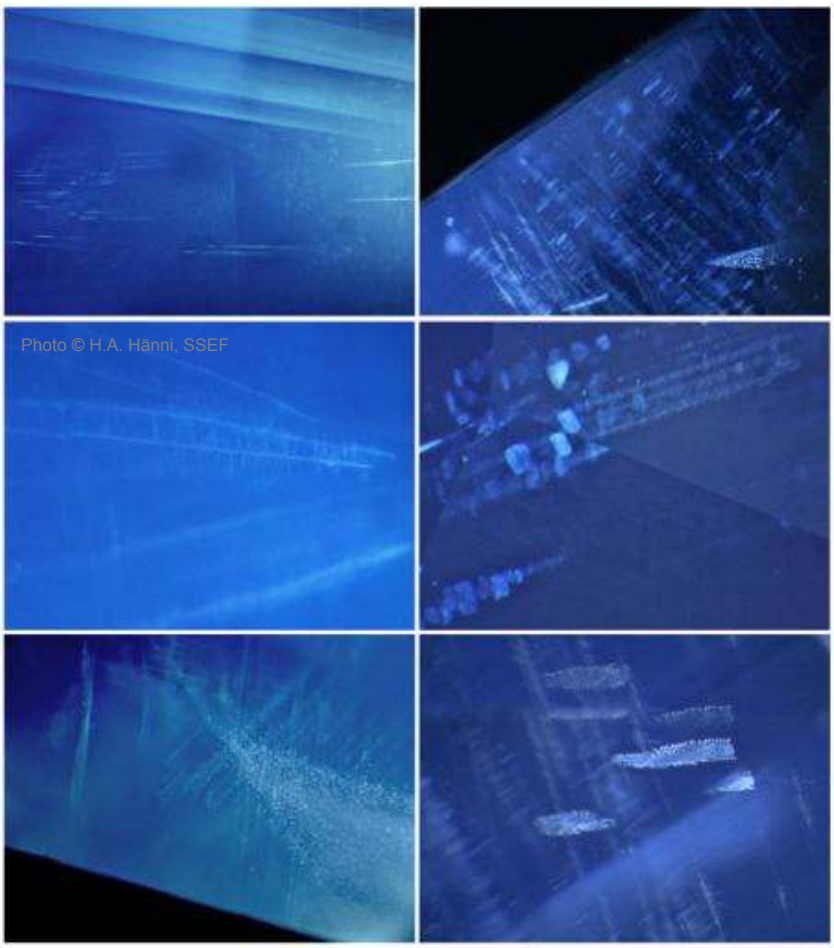
The Kashmir - Madagascar challenge !


Kashmir
Photo © H.A. Hänni, SSEF
Blocky zoning with red VIS-fluorescence
Madagascar
Very dense zoning
„Parquet“-structure
Dark grey colour layer (zone)


Kashmir
subtle „dust“ flakes and patches
Photo © H.A. Hänni, SSEF
Madagascar
dense and well-shaped (rhombic) „dust“ patches
SSEF

Kashmir

Fine and partly curved „dust“ lines and tracks



Madagascar

Distinct and straight „dust“ lines

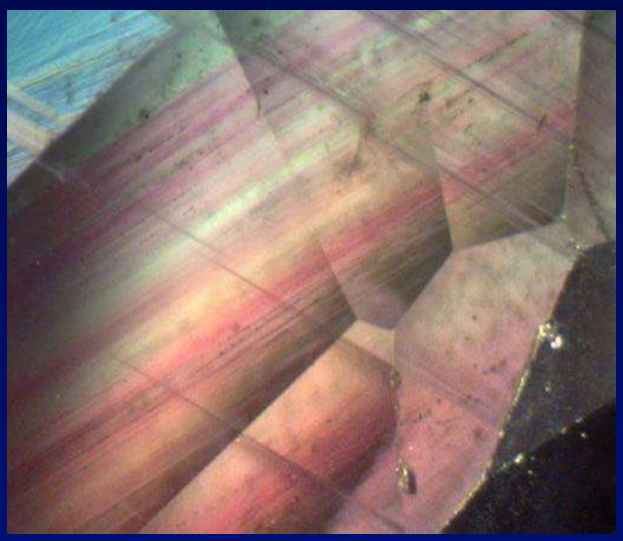
Kashmir – Sri Lanka – Madagascar - Basaltic

Usually quite included	Often rather pure	Often rather pure	Usually included
Characteristic blocky zoning	often narrow zoning	often narrow zoning with dark zones	Very regular narrow zoning
Characteristic Inclusions: - pargasite ...	Characteristic Inclusions: - apatite, diaspore...	Often only few inclusions	Characteristic Inclusions: - U-pyrochlore
Metamorphic UV-Vis spectrum	Metamorphic UV-Vis spectrum	Metamorphic UV-Vis spectrum	Basaltic UV-Vis spectrum
Low Fe Low Fe^{3+}	Low Fe Slightly higher Fe^{3+}	Higher Fe Slightly higher Fe^{3+}	High Fe High Fe^{3+}

New source: Fancy sapphires from Batakundi, Kashmir area (Pakistan)

Sleeping beauty ?

New source: Fancy sapphires from Batakundi, Kashmir area (Pakistan)



Usually included (graphite), milky and with distinct colour zoning (Cr).

Ruby

Burmese ruby

The ruby ring of Marie José, Queen of Italy

Mogok

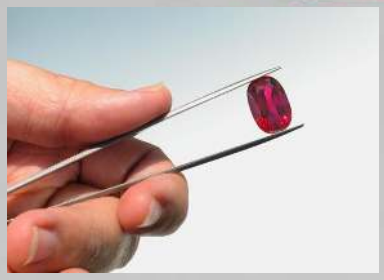
Gemmarket in Mogok (January 2014)


Dattaw mine : East of Mogok

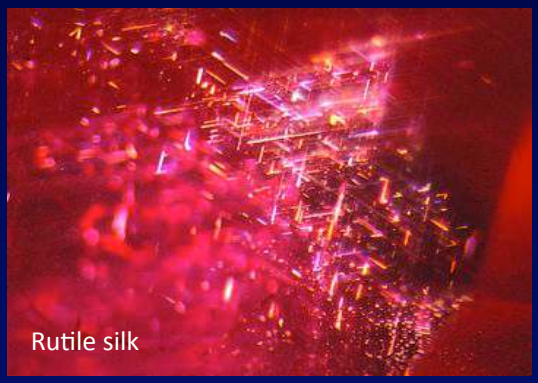

Ruby testing at SSEF

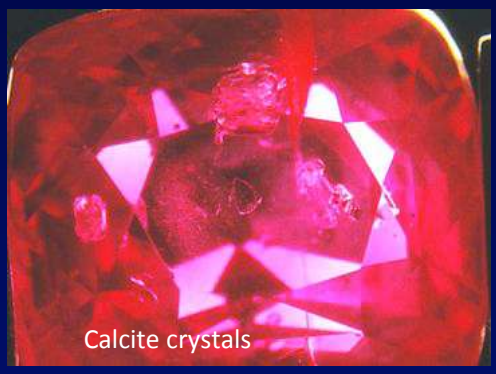
The quest for the perfect ruby from Mogok...

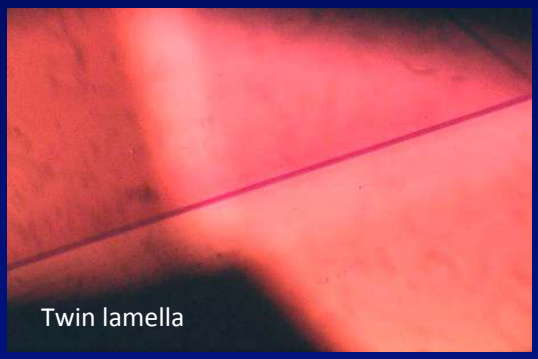
approx. 14 ct

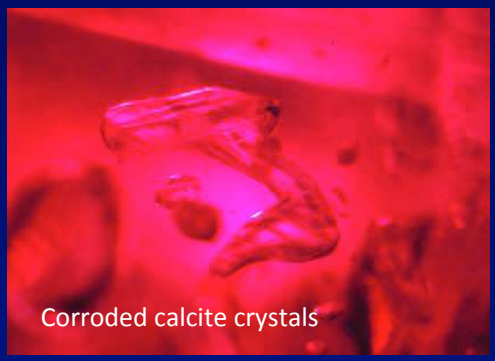


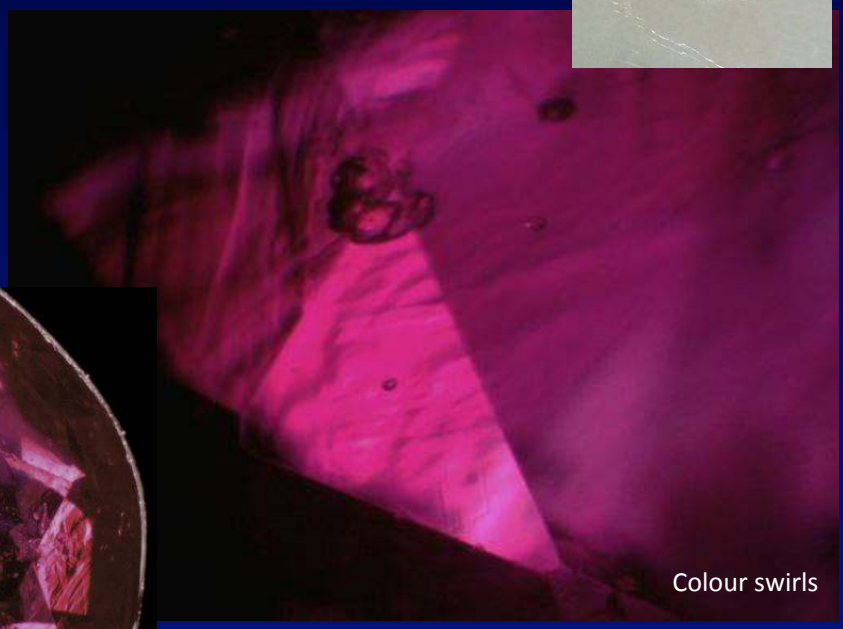
Inclusions in Ruby from Mogok



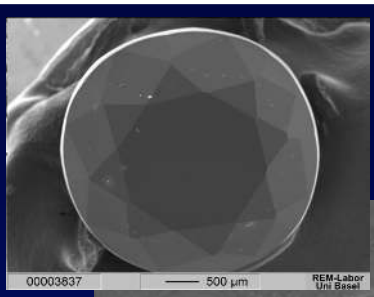


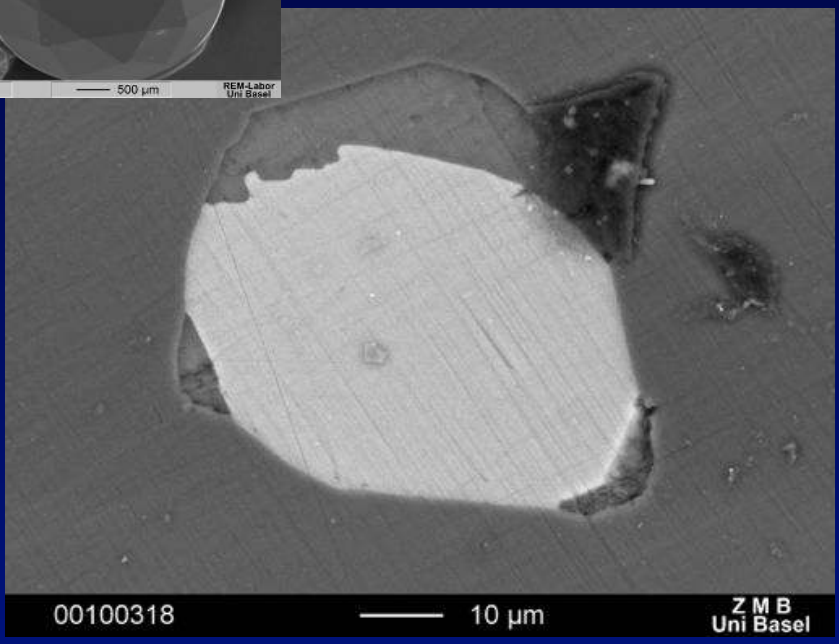




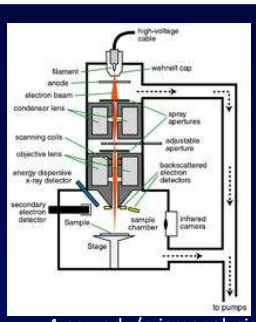


Scanning Electron microprobe

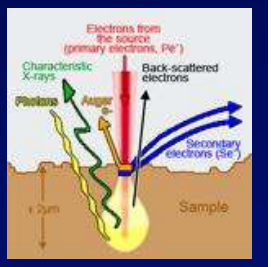




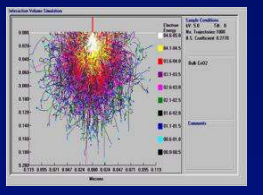
Titanite and plagioclase inclusion in ruby from Mogok



www4.nau.edu/microanalysis



www.vcbio.science.ru.nl



www.optics.rochester.edu


Burmese Ruby: approx. 48 cts


Approx. 48 cts
„Cut tongues“ and geometric (trigonal) platelets
SSEF

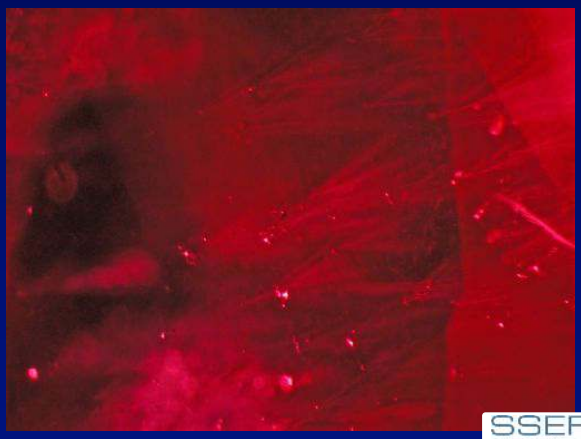
Many rubies from Mong Hsu have a dark blue core

Mong Hsu, unheated

Mong Hsu, unheated

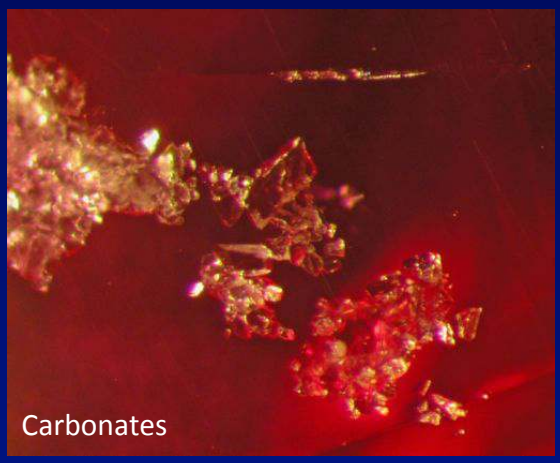
Cross clouds

Dust tracks „comets“



Mong Hsu, unheated

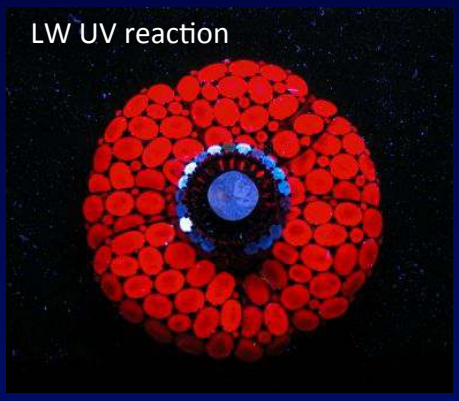
Zoning



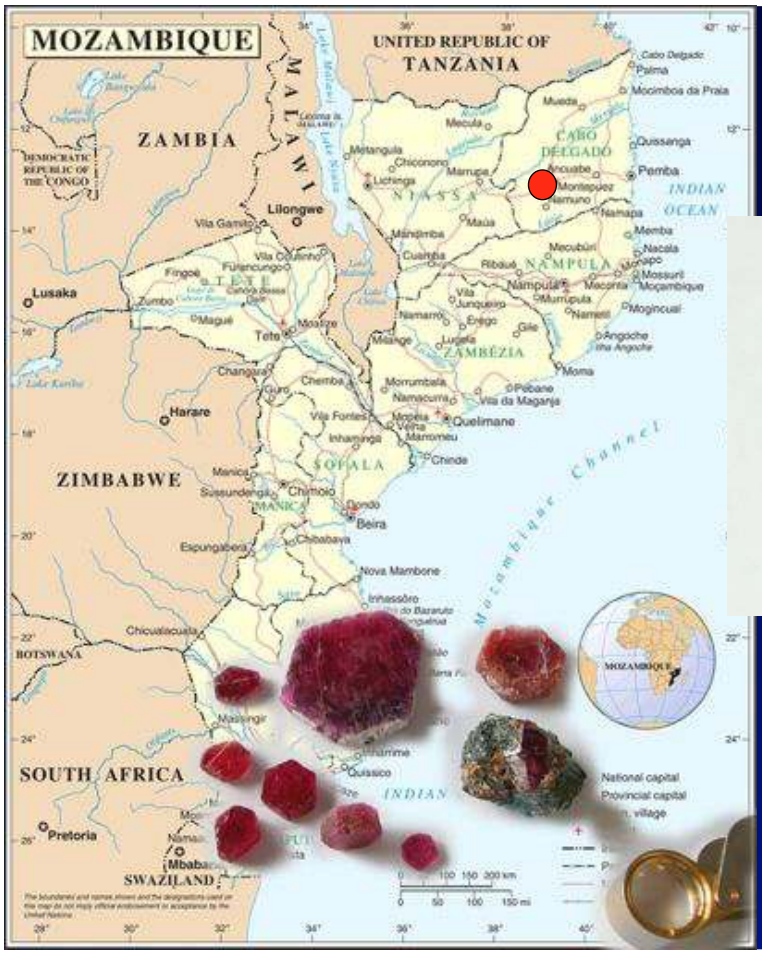
Carbonates

& healed fissures

Mong Hsu heated



Photos © H.A. Hänni, SSEF



New Ruby Deposit: Montepuez in Mozambique

Photo © H.A. Hänni, SSEF

Mozambique (Montepuez)

Rubies from Amphibolite

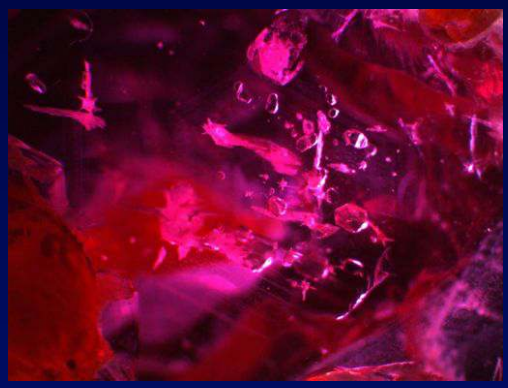
Photos © H.A. Hänni, SSEF

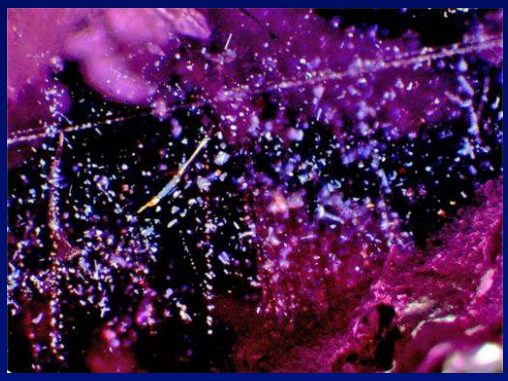
Montepuez Ruby

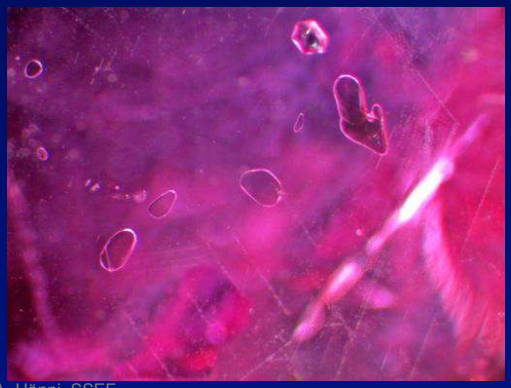
Inclusions:

Rounded crystal inclusions,
rutile needles, twinning planes,
green amphibole.

- Inclusions ± similar to Mogok, Burma
- Trace elements ± similar to Winza

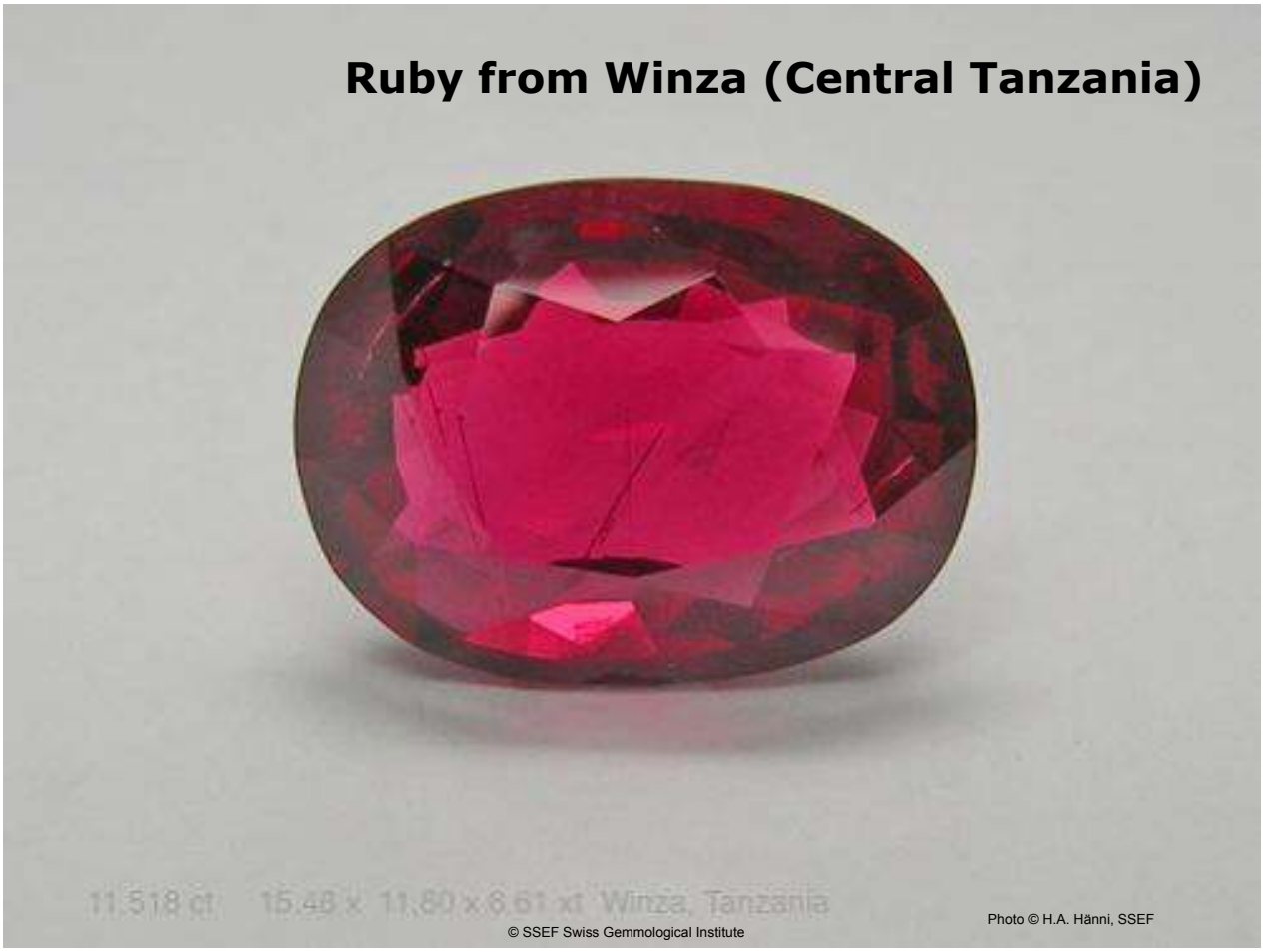






Photos © H.A. Hänni, SSEF

Ruby from Winza (Central Tanzania)



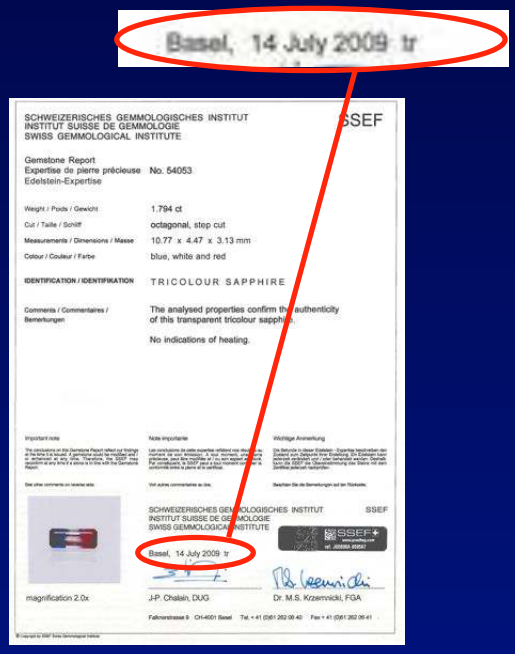
Rubies from Winza

Characteristic inclusions:

- curved hollow-channel
- whitish granular fluid inclusions
- blue to greyish colour zones

Colour zoning in corundum from Winza

Vive la France!



Basel, 14 July 2009 tr

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INSTITUT SUISSE DE GEMMOLOGIE
SWISS GEMMOLOGICAL INSTITUTE

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Gemstone Report
Expertise de pierre précieuse
Edelstein-Expertise

No. 54053

Weight / Poids / Gewicht	1.794 ct
Cut / Taille / Schliff	octagonal, step cut
Measurements / Dimensions / Masse	10.77 x 4.47 x 3.13 mm
Colour / Couleur / Farbe	blue, white and red
IDENTIFICATION / IDENTIFIKATION	TRICOLOUR SAPPHIRE
Comments / Commentaires / Bemerkungen	The analysed properties confirm the authenticity of this transparent tricolour sapphire. No indications of heating.

Important note

Note importante

Wichtige Anmerkung

magnification 2.0x

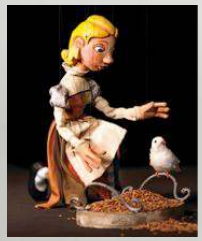
J-P. Chalain, DUG

Dr. M.S. Krzemnicki, FGA

New rubies and sapphires from Madagascar (Didy):

A ruby of 25 ct from Didy (Madagascar) showing an exceptional clarity

The Cinderella job....



Unheated Burmese rubies mixed with very few heated ones, or even synthetic rubies or ruby imitations (dyed quarzite)

The colour of ruby

Pigeon blood red

SSEF definition:
Poetical and historical colour term, describing a saturated and vivid crimson red colour of gemquality untreated rubies from Burma (Myanmar).

The SSEF does not apply this term to rubies from other sources, nor to heated stones.

At SSEF stones are compared to colour charts and reference stones.

Conclusions:

Origin of a gemstone should not be misinterpreted as a quality grade.

Origin determination is always a expert opinion

It is based on a combination of meticulous observations and analytical data

New analytical methods have made and will make important contributions, but due to overlapping properties, these data need careful interpretation (no black box !)

Still nowadays, microscopy is a very important and useful tool, as the presence, shape, and distribution of inclusions and zoning features are very sensitive markers of specific local formation processes.

New deposits may be a challenge for gemmologist, but are welcomed by the trade to answer the high demand in gems.