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

Origin determination of gemstones: Possibilities, Challenges and limitations

Dr. Michael S. Krzemnicki, Swiss Gemmological Institute SSEF

Photos © M.S. Krzemnicki, SSEF, except where indicated otherwise
The Star of Kashmir
Sapphire from Kashmir of approx. 20 ct,
Geneva May 2013, 3.5 mio US$ 
SSEF Test Report No. 66221

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
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 tectonometamorphic events (750-450 ma) by the collision of eastern and western Gondwana.

In mid-Jurassic (about 160 ma), India started to drift towards north.
Distribution of marble-hosted ruby deposits along the Himalayan orogeny (45-5 ma) due to the collision between the Indian plate and Eurasia.

**Corundum from alkali basalts**

Tertiary and quaternary basalts and related corundum deposits in South-East Asia.
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 inductive coupled plasma mass spectrometry)
- LIBS (laser induced breakdown spectroscopy)

Raman microspectrometry

© Swiss Gemmological Institute SSEF
UV-Vis Spectrometry

SAPPHIRE ABSORPTION SPECTRA


Chemical data versus spectroscopic data

SSEF-Diagramm Saphir

Basaltic
Burma
Ceylon
Kashmir

© SSEF Swiss Gemmological Institute
Laser Ablation Inductively Coupled Plasma Mass Spectrometry LA-ICP-MS

With Dr. Thomas Pettke at the Geochemical Lab, University of Berne, Switzerland

Laser ablation

Local heating and vaporization
Raw data

From: P. Halicki, SSEF (Masterthesis)

Data processing

Surface contamination !

Surface contamination !

Spikes !  Spikes !  Spikes !

From: P. Halicki, SSEF (Masterthesis)
Sapphire Results:

- Burma
- Madagascar
- Sri Lanka
- Kashmir

Fe (ppm) vs. Ti (ppm) graph showing distribution of sapphire results from different localities.
Sapphire Results:

From: P. Halicki, SSEF (Masterthesis)
Comparison: Peucat et al (2007) vs. Kashmir this study

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

Possibilities & Limitations:

From: P. Halicki, SSEF (Masterthesis)
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.

Characteristic inclusions in Kashmir sapphires

Zoning pattern
no rutile needles in Kashmir sapphires!

Subtle „dust“ tracks

© Swiss Gemmological Institute SSEF
Characteristic inclusions in Kashmir sapphires

Pargasite needles (prismatic)

Corroded plagioclase

Short-prismatic greenish dravite (tourmaline)

Prismatic but corroded zircons

The Kashmir - Madagascar challenge!
Kashmir

Blocky zoning with red VIS-fluorescence

„Parquet“-structure

Madagascar

Very dense zoning

Dark grey colour layer (zone)

Kashmir

subtle „dust“ flakes and patches

Photo © H.A. Hänni, SSEF

Madagascar

dense and well-shaped (rhombic) „dust“ patches
### Kashmir – Sri Lanka – Madagascar - Basaltic

<table>
<thead>
<tr>
<th></th>
<th>Usually quite included</th>
<th>Often rather pure</th>
<th>Often rather pure</th>
<th>Usually included</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic blocky zoning</td>
<td></td>
<td>often narrow zoning</td>
<td>often narrow zoning with dark zones</td>
<td>Very regular narrow zoning</td>
</tr>
<tr>
<td>Characteristic Inclusions:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- pargasite ...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristic Inclusions:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- apatite, diaspore...</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metamorphic UV-Vis spectrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Fe(^3+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metamorphic UV-Vis spectrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Fe(^3+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metamorphic UV-Vis spectrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slightly higher Fe(^3+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metamorphic UV-Vis spectrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basaltic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Fe(^3+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
New source: Fancy sapphires from Batakundi, Kashmir area (Pakistan)

Sleeping beauty?

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

Burmese ruby

The ruby ring of Marie José, Queen of Italy

Courtesy of Albion Art collection
Mogok

Gemmarket in Mogok (January 2014)
Introduction

Jade, (since) (thousand of) (years) (a) (mythical) (stone) (appreciated) in (Far East) and (in) (the) (cultures) (of) (native) (Americans,) (is) (currently) (again) (rising) (high) and (is) (sought after) (at) (auctions) (in) (Hong Kong) and (elsewhere.)

Ruby testing at SSEF
The quest for the perfect ruby from Mogok...

approx. 14 ct

Inclusions in Ruby from Mogok

Rutile silk
Calcite crystals
Twin lamella
Corroded calcite crystals

Photos © H.A. Hämm, SSEF
Colour swirls

Generally included

105 ct

© SSEF Swiss Gemmological Institute

Titanite and plagioclase inclusion in ruby from Mogok

Scanning Electron microprobe

www4.nau.edu/microanalysis
www.vcbio.science.ru.nl
www.optics.rochester.edu

© SSEF Swiss Gemmological Institute
Burmese Ruby: approx. 48 cts

“Cut tongues” and geometric (trigonal) platelets

Approx. 48 cts
Mong Hsu, Burma
important source of rubies since the 90ies

Many rubies from Mong Hsu have a dark blue core

Mong Hsu, unheated

Dark blue to black core zone (Ti-enriched)
Mong Hsu heated

New Ruby Deposit: Montepuez in Mozambique
Mozambique (Montepuez)

Rubies from Amphibolite

Inclusions:
- Rounded crystal inclusions,
- Rutile needles, twinning planes,
- Green amphibole.

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

Montepuez Ruby

Photos © H.A. Hänni, SSEF

© Swiss Gemmological Institute SSEF
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!

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 quartzite)

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.