## The Origin Determination of Gemstones:

# Challenges and Perspectives

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Every gemstone has an origin that can be understood in terms of geological setting or geographical location. For the final customer, only the latter is relevant. Terms such as *Kashmir* for sapphires, *Burma* for rubies, and *Colombia* for emeralds evoke a historical and cultural context combined with an exotic flavor, which may contribute considerably to the value of a gemstone. That's why the trade requests that gemological laboratories perform origin determination. Although this problem is quite specific to gemology, similar kinds of expertise are well established in other areas, such as the authentication of works of art, wine, historical manuscripts and even criminal forensics. All of these approaches combine scientific analysis with careful interpretation of visual observations, backed by long experience in the relevant field.

There have been many outstanding articles about origin determination in the professional gemological literature in the past three decades. Gübelin and colleagues adopted a rather microscopic approach in the 1980s (see e.g. Gübelin & Koivula, 1986). Building on this, the SSEF Swiss Gemmological Institute introduced chemical and spectroscopic criteria to origin determination in the early 1990s (see e.g. Hänni et al. 1994). Criteria such as crystal growth characteristics and inclusion identification using a Raman microprobe have further contributed to the understanding of gemstone origins. By combining such analytical results and microscopic observations with information about the geological setting of the mining sites, experienced gemmologists can deduce the geographic origin of a ruby, sapphire, emerald, alexandrite, or copper-bearing elbaite tourmaline, if there is sufficient evidence present within the stone.


SSEF
TEST REPORT No. 00000
on the authenticity of the following gemstone, mounted in a brooch with diamonds

| | |
|---|---|
| Shape & cut: | antique cushion, modified brilliant / step cut |
| Total weight: | approximately 27.5 grams (including mounting and diamonds) |
| Measurements: | approximately 24.10 x 14.05 x 12.40 mm |
| Calculated weight: | approximately 41 ct |
| Colour: | blue of medium saturation |
| Identification: | SAPPHIRE (variety of corundum) |
| Comments: | The analysed properties confirm the authenticity of this transparent sapphire. No indications of thermal enhancement. Origin: Kashmir |

SSEF - SWISS GEMMOLOGICAL INSTITUTE
Gemstone Testing Division
Basel, 6 August 2001
SPECIMEN
Dr. L. Kiefert, FGA Prof. Dr. H.A. Hänni, FGA

***Fig 3:* SSEF Test Report of an important 41 carat sapphire from Kashmir, mounted in a brooch with diamonds.** *© H.A. Hänni, SSEF*

***Fig 1:* Rough and faceted sapphires from Kashmir. Top-quality stones from Kashmir are highly prized for their velvety blue colour due to light scattering by tiny particles in the stone.** *© H.A. Hänni, SSEF*

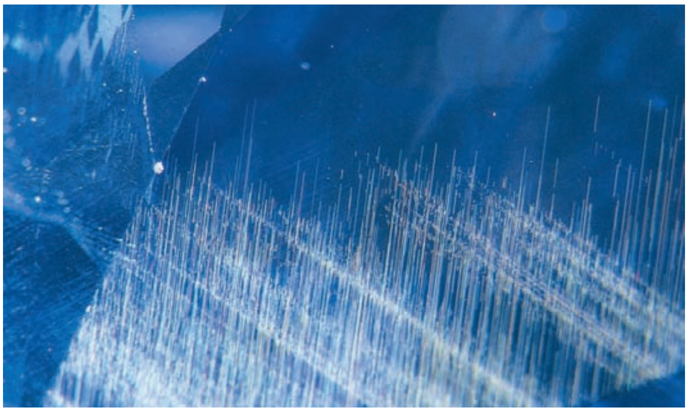

***Fig 2:* Fine and dense rutile needle aggregates are typically found in sapphires from Myanmar (Burma). Stones from Sri Lanka display long rutile needles, whereas sapphires from Kashmir show nearly no rutile inclusions.** *© H.A. Hänni, SSEF*

An origin determination in a printed gemstone report is always an opinion, based on the existing knowledge of the gemmologist(s) in the laboratory that prepared it. Different laboratories may have different philosophies of origin determination, resulting in different origin determinations for the same gemstone. Although this seems quite unsatisfactory, the most prominent labs in the field of origin determination, such as SSEF, AGTA GTC and Gübelin, regularly share their latest research results with the express aim of cutting down on the number of such ambiguous situations.

As one of the most prominent proponents of a scientific approach to origin determination, the SSEF has put a lot of effort into research on gemstone deposits, accumulating a large collection of reference samples in the process. This collection is very important and acts as a research database for origin determination. It is the philosophy of SSEF that only by sharing our knowledge with other labs, gem dealers, and miners can we maintain a high level of expertise for gemstone origin determination in the future. For those who are interested, SSEF offers advanced gemological courses on origin determination

***Fig. 4:* Rough sapphires and rubies of different origins form part of the SSEF reference collection.** *© H.A. Hänni, SSEF*

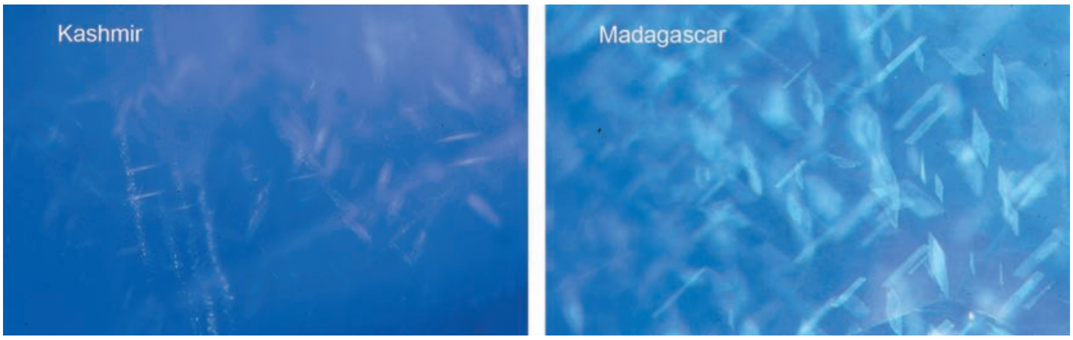


***Fig 5:* Since the inclusions in sapphires from different origins often look quite similar, careful observation and description are required for correct interpretation of these features. In sapphires from Kashmir, whitish particle-flakes are rounded, whereas in visually similar sapphires from Madagascar, these flakes show a distinct rhombic outline.** *© H.A. Hänni, SSEF*

and scientific methods in gemology on a regular basis (see www.ssef.ch).

The determination of gemstone origins has always been and continues to be a challenging task, as new gemstone deposits are constantly emerging, especially in East Africa and Madagascar. Although not all of these new deposits are commercially important for the trade, gemological laboratories have to collect samples and information about all such new finds and update their databases accordingly. As a result of these new finds, many formerly accepted criteria have to be reconsidered for their consistency. Sometimes situations arise in which gemstones from these new deposits are not easily distinguished from material from well-known mining sites. Examples include copper-bearing elbaite tourmalines ("Paraiba") from Mozambique and Nigeria, sapphires from Madagascar and rubies from deposits of dolomite marble along the Himalayan mountain range in Afghanistan and neighbouring countries. Another challenge is to integrate new analytical tools so that they become part of routine laboratory gemstone analysis. Methods such as

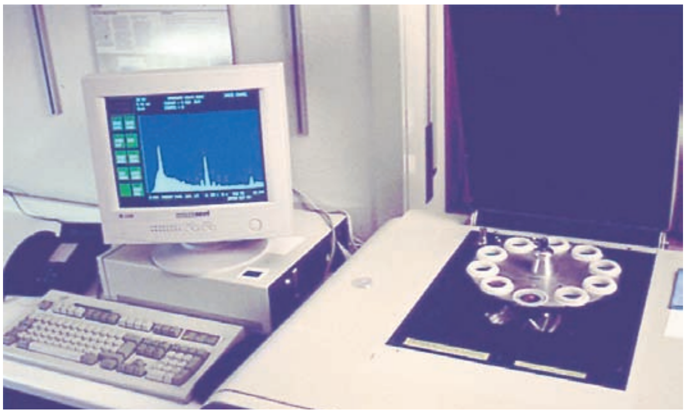

***Fig. 6:* Energy-dispersive X-ray fluorescence (ED-XRF) for chemical analysis. This instrument is used routinely in many gemological laboratories.** *© H.A. Hänni, SSEF*

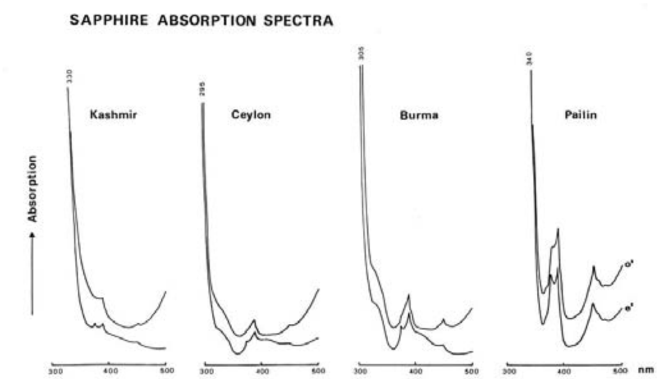


***Fig. 7:* Normalized UV-VIS spectra of sapphires originating from different mining sites (from Hänni 1994).**

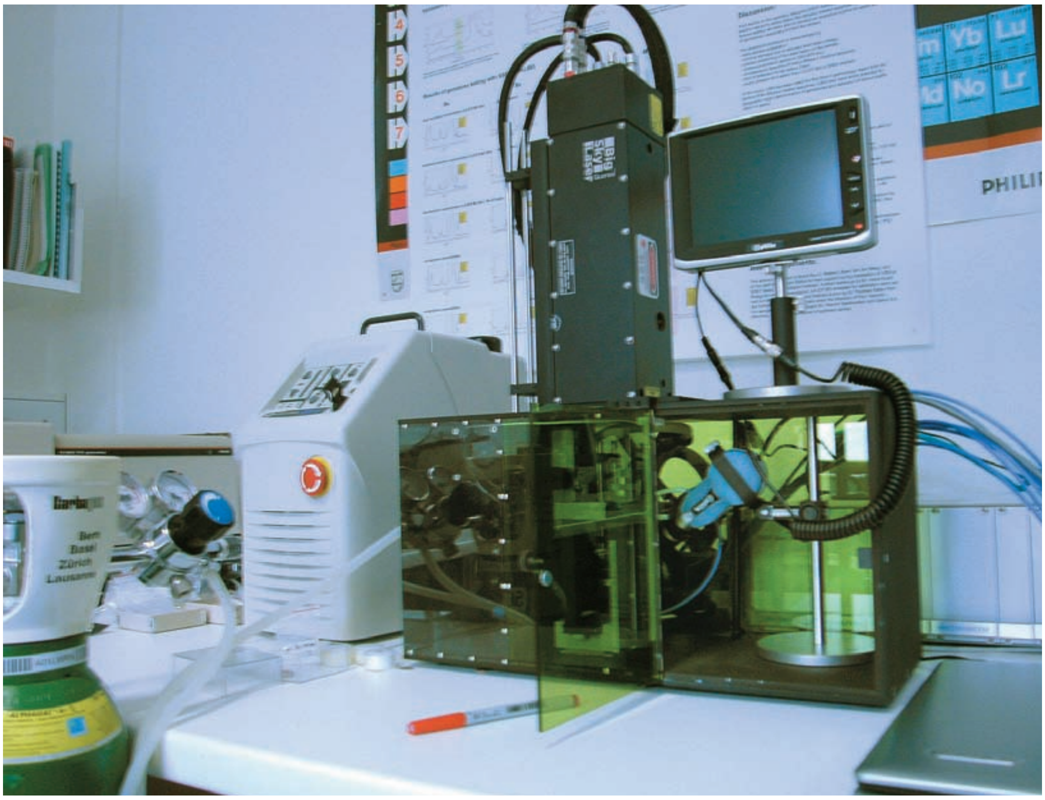

***Fig. 8:* SSEF Gem-LIBS. Chemical analysis of gemstones using a laser.**
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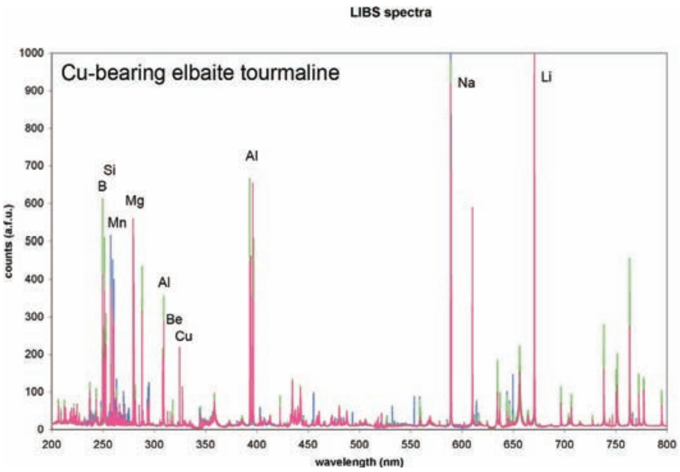
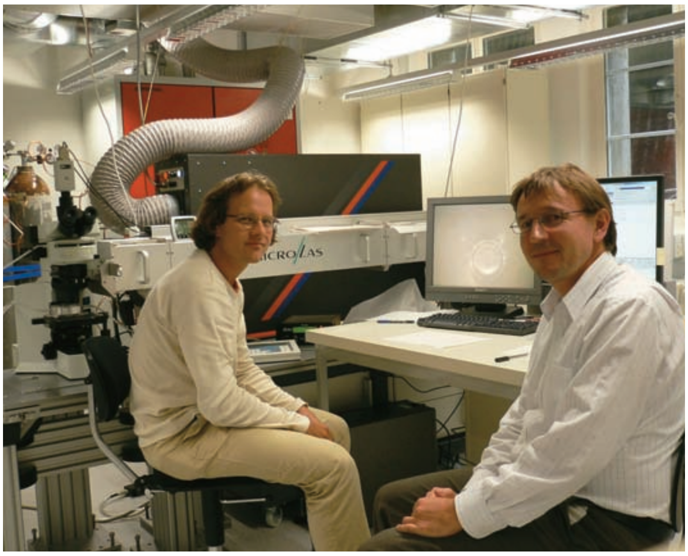



**Fig. 9:** ***LIBS spectra of copper-bearing elabite tourmalines, showing characteristic emission lines of light elements such as boron, beryllium and lithium. These elements cannot be analysed by ED-XRF.*** *© M.S. Krzemnicki, SSEF*

LIBS (laser induced breakdown spectroscopy) and LA-ICPMS (laser ablation ICP mass spectrometry), which have been used for years in chemistry and geology, are of growing importance in gemology (Krzemnicki et al. 2004, Guillong & Günther 2001, Abduriyim & Kitawaki 2006). With these methods, we can gain access to many more chemical elements at distinctly lower detection limits than with the commonly used method of energy-dispersive X-ray fluorescence. Stable isotopes can provide information about the geological setting of a gemstone deposit (Guiliani et al. 1998), but not all of these methods are readily available to laboratories, and when they are, they often require careful analytical procedures to avoid misinterpretation of the results.

In the future, experts trying to determine the origin of gemstones will still have to make use of classical microscopic observations and get as much chemical and spectroscopic information as possible. As the amount and reliability of chemical data continues to increase thanks to the technologies mentioned in this brief review, gemological laboratories will have to implement statistical methods to handle the large amount of new data.



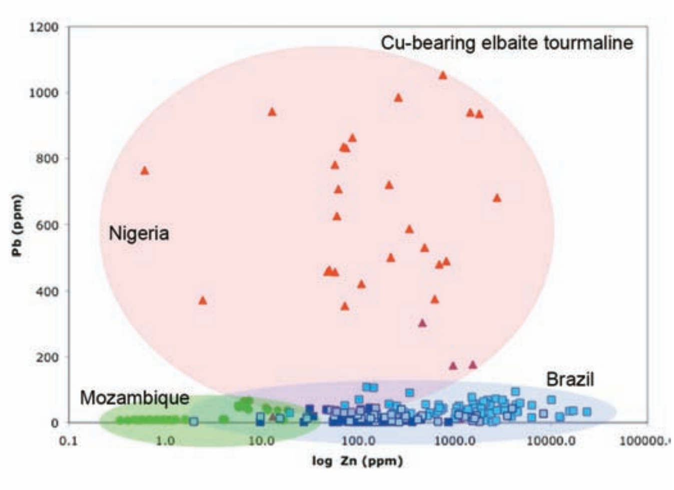



**Fig. 11:** ***Diagram based on LA-ICP-MS analyses of lead and zinc in copper-bearing elbaite tourmalines from Nigeria (red triangles), Mozambique (green circles) and Brazil (blue squares). Although some overlap occurs, origin determination can be done on the basis of a series of such diagrams of "Paraiba" tourmalines.*** *© M.S. Krzemnicki, SSEF*

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**Fig 10:** ***Prof. Dr. Pettke together with Dr. Michael S. Krzemnicki (SSEF) in the Geochemistry LA-ICPMS Laboratory of the Institute of Geology, University of Berne, Switzerland.*** *© M.S. Krzemnicki, SSEF*