Origin Determination of Gemstones: Challenges and Perspectives

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Abstract
Every gemstone has an origin. The origin can be understood in terms of geological setting, and in a 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 flavour, which may contribute considerably to the value of a gemstone. That's why the trade requests origin determination from gemmological laboratories.
Origin determination has been described in gemmological literature in the past three decades with many outstanding contributions. Starting from a rather microscopic approach in the 80ies by Gübelin and co-workers (Gübelin & Koivula, 1986), Hänni et al. (1994) introduced chemical and spectroscopic criteria in origin determination. Further criteria such as crystal growth characteristics and inclusion identification using a Raman microprobe have also contributed to the understanding of origin determination. As one of the driving forces of a scientific approach for origin determination, the SSEF Swiss Gemmological Institute has invested many efforts in research on gemstone deposits, and accumulated a large collection of reference samples and experience in this field. Thus, combining analytical results and microscopic observations with information about the geological setting of the mining sites enables us and other well-experienced and trained gemmologists to deduct the geographic origin of a ruby, sapphire, emerald, alexandrite, and copper-bearing elbaite tourmaline, if there is sufficient evidence present within the stone. An origin written on a gemstone report is always an opinion, based on the present knowledge of the gemmologist(s) in a laboratory. Different laboratories may have different philosophies for this task. A simplistic approach using some clue features for separation into "source" types cannot compete with a scientific approach.

The determination of a gemstone origin has been and still is 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, gemmological laboratories have to collect samples and information about such new findings and update their database. As a consequence of such new findings, many former criteria have to be reconsidered for their consistency. Examples for such a situation with new deposits, which are not easily separated from material of classical mining sites include the copper-bearing elbaite tourmalines ("Paraiba") from Mozambique and Nigeria, the sapphires from

Madagascar, and rubies from deposits in dolomite marbles along the Himalayan mountain range (Afghanistan etc.). Another challenge is the integration of new analytical tools into the routine of gemstone analysis in the laboratory. Especially methods such as LIBS and LA-ICPMS, which have been used for years in chemistry and geology, are growing in importance in gemmology (Krzemnicki et al. 2004, Guillong & Günther 2001, Abduriyim & Kitawaki 2006). With these methods, we gain access to much more chemical elements and at distinctly lower detection limits as with the commonly used EDXRF. Stable isotopes provide information about the geological setting of a gemstone deposit (Guiliani et al. 1998). Not all of these methods are readily available to laboratories. Furthermore, these methods often require careful analytical procedures to avoid misinterpretation of the results.

As a future perspective, origin determination of gemstones will still have to integrate classical microscopic observations, with as much as possible chemical and spectroscopic information. As the amount and reliability of chemical data will increase in future due to above mentioned technologies, gemmological laboratories will have to implement a robust and structured deduction method (e.g. factor analysis or neural network) to handle the large amount of collected data.

References:

Abduriyim A. and Kitawaki H. (2006) Applications of Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) to Gemmology. Gems & Gemology, Vol.42, No.1, pp. 98-118

Giuliani G., France-Lanord C., Coget P., Schwarz D., Cheilletz A., Branquet Y., Giard D., Martin-Izard A., Alexandrov P., Piat D.H. (1998) Oxygen isotope systematics of emerald: relevance for its origin and geological significance. Mineralium Deposita. Vol. 33, No. 5, pp. 513-519

Gübelin E.J., Koivula J.I. (1986) Photoatlas of inclusions in gemstones. ABC Editions, Zurich

Guillong M., Günther D. (2001),Quasi "non-destructive" Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) fingerprinting of sapphires. Spectrochim. Acta., B vol. 56, No. 7, pp. 1219-123

Hänni, H.A. (1994) Origin determination for gemstones: possibilities, restrictions and reliability. J. Gemm., Vol. 24, No. 3, pp 139-148

Krzemnicki M.S., Hänni H.A., and Walters R.A. (2004) A New Method for Detecting Be Diffusion¿Treated Sapphires: Laser-Induced Breakdown Spectroscopy (LIBS) Vol. 40, No. 4, pp.314-322