Advancements in Gemmological Instrumentation over the Last 30 Years

Prof. Dr H.A. Hänni, *FGA, SSEF Swiss Gemmological Institute, Basel*

自七十年代末期起，寶石行業經歷鑽石熱潮及大量新的合成寶石面世，引致各樣先進的寶石鑑證儀器之出現，例如分光光度計、傅立葉轉換紅外光譜分析儀(FTIR)、能量散射X光螢光分析儀(EDXRF)、雷射剝蝕感應耦合電漿質譜儀(LA-ICP-MS)、光放射光譜(LIBS)、光纖燈、拉曼光譜儀等等。各項儀器，除了價值高昂外，亦需要高度受訓及高技術的寶石鑑證師安全及靈巧地操作使用。

The late seventies were characterised by the diamond boom and the appearance of a number of new synthetic gemstone materials. A gemmologist's equipment usually consisted of a 10x loupe, a refractometer, a polariscope, and a spectroscope. A variety of microscopes were available, equipped for dry or immersion, monocular or binocular microscopy. Only rarely was a spectrophotometer encountered in a gemmological laboratory. And only when problems arose in colour authenticity detection by spectroscope, did the laboratory boards become convinced that they should invest in a spectrophotometer. Later this piece of equipment became almost standard and today Varian and Perkin Elmer instruments are often seen. For diamond colour origin identification low-temperature spectroscopy was introduced and this type of spectra became required data for in-depth knowledge of diamond treatment. Soon, though, the laboratory boards were once again in difficulties because the labs badly needed the Fourier Transform Infrared FTIR spectrometers to identify the type of diamond they were working with, and the aggregate ratios.

Because of Chatham, Kashan and Ramaura synthetic rubies which were often fairly free of inclusions, trace chemical analysis became an issue. Energy dispersive x-ray fluorescence especially provides quick and non-destructive chemical information. The price for an EDXRF, however, is still quite high today so that the number of these instruments in gemmological laboratories is still small. Today the results required are not only for Gallium in natural corundum or chrysoberyl. EDXRF technique is also very helpful in origin determination. Variety determination such as for Paraiba tourmaline also depends on elemental analysis, in this case of Mn, Cu, Sb, Pb. Such semi-quantitative results may resolve many disputed cases, but a quantitative determination of trace elements is always a better choice for a safe identification and separation as e.g. between gemstones from different deposits. As a result, mass spectrometry (LA-ICP-MS) is being used more and more in gemmological laboratories. Optical emission spectroscopy (LIBS) may to some extent do a similar service. The results, however, are not quantitative, but the lower detection limit compared to EDXRF is often a feasible alternative for a lower price.

The fear of synthetic stones also enhanced the use of FTIR analysis particularly when natural and synthetic emeralds were to be separated. But the most important use of FTIR is for mineral identification with KBr tablets, an application that is adapted in gem testing by a modified diffused reflectance technique.

The gemmological challenges of the last ten years have been more in the identification of treatments. Since approximately 1985 the identification of treated gemstones has become more and more difficult. Different treatment techniques are in use depending on the nature of the material, including coating, irradiation, bombardment, heat treatment, and diffusion-treatment, fracture filling, laser drilling and so on. As a consequence, once again quite a number of analytical instruments have become important tools for the identification of these treatments. While a lot of the treatments can be observed simply with optical inspection, providing proof for a sound identification must be done with instruments. Not all treatments have the same pressing need to be identified. There is more pressure to identify heat treated-corundum than irradiated topaz, so gamma spectrometers are less abundant in gem labs than is the knowledge of glass residue identification.

The real advancement during the last 25 years has not been with the 10x lens, which had a drop shape in the older days and has a hexagonal shape today. The real step forward has been the improvement in lighting. Affordable and light-weight fibre lights bring cool light to the place where it is needed. Foldable flip lamps are carried along to viewings and provide the perfect lighting conditions for examination of diamonds. Diode lights are now used for monochromatic light in refractometers.

Another tremendous addition to the analytical arsenal is the Raman spectrometer. The author saw the first Raman system in France, and it filled a whole laboratory. A few years later at Nantes University they already had a Dilor desk model. The first Renishaw system the author saw was in the AIGS Lab in Bangkok and then the CISGEM Lab in Milan joined the club. The SSEF Raman was needed for spot identification of fracture fillings in emeralds. When, in 2000, the HPHT treated type II diamonds posed an identification problem, the highly effective spectrometer of the Raman system was used to register the luminescence spectrum produced by the 514 nm laser source. It was due to this modern piece of equipment that SSEF was the first gemmological laboratory able to identify the HPHT treated type II diamonds. The need to identify beryllium in trace levels in cut sapphires has again pushed forward the wheel of laboratory instrumentation. Since laser ablation inductively coupled mass spectrometry LA-ICP-MS was good enough but too expensive, another method for Be detection had to be found. LIBS has now proved to be affordable, precise and practical enough to fill the gap. All these advancements in instrumental equipment were only made possible by the support of the SSEF board members who always came up with the money through special events or campaigns collecting from the trade. But they would not have made the timely and wise decisions to acquire all the necessary pieces of equipment without the desperate cries of their laboratory and research gemmologists.

A number of analytical techniques and instruments have not been mentioned so far, although they have been delivering extremely valuable results which have solved important gemmological problems: SEM, isotope analysis, Laser tomography, PIXE, to name only a few.

The instrumental equipment of a gemmological laboratory and the necessary armaments to deal safely with the present merchandise is a costly matter. It is not just that the instruments have a value of more than a million dollars. Their safe manipulation and the clever interpretation of the resulting spectra require highly educated scientific gemmologists, far beyond that of the FGA or GG diploma standard. And this situation, too, is an advance that has been made in our gemmological laboratories.

Fig. 1 Scientific instruments in the SSEF analytical laboratory