CSI GEMOLOGY

Where will the future of gemology take us?

Newer, faster, and often more complex instruments provide the technological muscle to answer many modern questions, from a murderer's identity to the composition of Martian rocks. So why is it that the deeper we peer into the mysteries of gemstone chemistry, the more uncertainties we uncover? Why haven't gemologists yet developed a way to definitively identify gemstone compositions, treatments, and origin?

One problem, says Steve Lowry, chief scientist for Thermo Fisher Scientific Inc. (a maker of instruments used in the gem trade), is that the current demands of the gemstone industry aren't enough to justify extensive investment in research and development. Rather, gemological laboratories must customize instruments and techniques derived from other industries, like semiconductors and photovoltaics.

Another problem, says Nicholas Del Re of European Gemological Laboratory (EGL USA), is that change in the gem industry only comes in times of crisis. Currently, gem technology is being driven by the sophisticated techniques used by gem treaters and creators. It's similar to performance-enhancing drugs in sports, says Lowry. "No sooner do you catch one then they make another."

As treatments and synthetics evolve, gemologists are forced to adopt increasingly advanced — and costly — analytical techniques to assure a gem's pedigree. This is leading to expensive

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Without advanced degrees, gemologists will have a hard time keeping up.

equipment investment, data interpretation challenges, growing research commitment, and, some experts say, the inevitable stratification of laboratories into a handful of elite powerhouses, with all the rest scrambling to keep up with the trade's rapidly changing needs.

Conflict Escalation

Until the mid-1990s, most labs relied on the keen observations of trained gemologists and a handful of basic equipment, including microscopes, refractometers, polariscopes, balances, and a variety of ultraviolet (UV) light sources. Some labs adopted Fourier transform infrared spectroscopy (FTIR) and energy dispersive X-ray fluorescence (EDXRF) instruments. With the advent of controversial emerald treatments, gemologists turned to Raman spectroscopy, which required extensive training to operate. The discovery of beryllium treatment of corundum required another step up, and laser-induced breakdown spectroscopy (LIBS), laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) and even secondary ion mass spectrometry (SIMS) were used to detect treatments.

"The number of analyses that require sophisticated analytical equipment increases each year along with the introduction of new — or variations upon old — treatments and synthetics," says Ken Scarratt, head of the Gemological Institute of America (GIA) Research (Thailand). "As each new instrument is added to deal with particular issues, the requirements placed on premises and staffing escalates."

Instruments like LIBS and LA-ICP-MS can cost between $75,000 and $300,000. SIMS equipment runs upward of $750,000. Laboratory facilities must be upgraded to provide the climate-controlled rooms and 24/7 monitoring required to maintain the advanced instruments.

Few labs can afford the equipment. Along with the high price tag, the instruments require painstaking set-up and calibration, adding time and cost to each analysis. Data interpretation also takes longer. All of this forces gemologists to spend much more time evaluating a single stone. The labs that can afford the initial investment along with the running costs will struggle with the testing fees they need to charge, says Scarratt.

"Currently, I only hear that the lab reports are too expensive," says Lore Kiefert, director of the American Gem Trade Association Gemological Testing Center (AGTA GTC) in New York. "But if you see what work goes into one gemstone, they are still not expensive enough."

Not only will prices continue to rise, but many labs will be challenged to provide all the services required by the trade. The trade should therefore have an interest in supporting the labs, so they can maintain their services at the highest level, says Michael Krzemnicki, deputy director of the SSEF Swiss Gemmological Institute.

One solution to escalating costs is to computerize analyses, says Lowry. "Many gemstones will have to be analyzed each day to cover the costs of these instruments," he says. "This may lead to a 24-hour operation with automated sampling." Increased throughput should lower costs, but would require collaboration between equipment manufacturers and gem labs to get it right.

Another option is for labs to divide up the analytical pie — for example, one laboratory specializing in SIMS while another perfects LA-ICP-MS — and cooperate. Ken Scarratt foresees the eventual development of specialized labs sharing information.

Kiefert, however, fears that a growing technological gulf between labs will result in a three-tier stratification. Traditional labs with basic equipment will identify stones but will not be able to address issues of treatment or origin. Mid-tier labs may have some high-tech equipment but will struggle to stay abreast of the latest developments. Only highly sophisticated labs will have the resources to pursue technological innovation, partnering with universities and industry to access skilled scientists and advanced technologies, such as stable isotope analysis for origin determination.

Staffing for Tomorrow

It isn't enough to buy bigger and better instruments; laboratories must also change how they hire staff. In the past, a classic gemological education was good enough. Now, interpreting the results of advanced chemical analysis into a language and answer useful to the gemologist requires experience in both chemical analysis and gemstone characterization, says Lowry. Solid knowledge of mineralogy and physics will also be important, says Krzemnicki, while Emmanuel Fritsch of the Institut des Matériaux Jean Rouxel in France suggests that gemology labs should recruit scientists with advanced degrees.

Kiefert agrees. Without advanced degrees, like those offered at the University of Nantes, France, and the University of Mainz, Germany, or advanced courses offered at the SSEF, gemologists will have a hard time keeping up, she says.

Still, that might not be enough. "Even for a gemologist with an excellent education in sciences, the operation of, and the understanding of data produced by, instruments such as LA-ICP-MS may be daunting," says Scarratt. In addition, with micro-destructive techniques like LIBS and LA-ICP-MS, operators must be exceptionally skilled to minimize damage to the stone. Laboratories may eventually be forced to diversify staff, hiring a broader mix of specialists capable of running the instruments and interpreting the data and gemologists who know enough to ask the right questions.

All of this — advanced degrees and larger staff — drive up laboratory overhead and contribute to higher analysis costs. And some fear that there are not enough young professionals entering the field to meet the growing demand.

Finally, despite the unquestioned need for advanced education, Fritsch says that labs shouldn't lose sight of the importance of basic gemological skills. "Classical gemology is still the most useful way to solve gemological issues," he says. "We are in a phase in which we are losing such knowledge, with the great names of classical gemology retiring or passing away, and not enough younger people being transmitted the knowledge accumulated. This is a serious problem, overlooked by people fascinated by whatever is new and trendy, to the detriment of what is truly useful, in particular to the jeweler gemologist."

Collaborators Wanted

As the data generated by advanced analytical techniques increases, gemologists need standards, databases, and other reference material to be able to make sense of it all. "We clearly need more fundamental research into gem materials, and certain projects, such as RRUFF™, are of great importance," says Scarratt. The RRUFF™ Project is a database compiled and maintained by the University of Arizona which includes Raman spectra, X-ray diffraction, and chemical data from approximately 2,000 different mineral types. "However, it is unlikely that many of these projects will be taken up in research establishments outside the industry. Therefore, gem laboratories will, and indeed have to, take up this challenge."

Once again, only the largest labs will be able to afford the added cost burden of research. The other problem is time. "When I have my everyday work to do and try to get gemstone reports out as fast as possible, I don't have time to travel around and do research," says Kiefert. "This would be true for most gemstone laboratories."

Greater collaboration between museums, universities, and laboratories would help, says Kiefert. "As long as that doesn't happen, every lab just has to put more effort into their own work."

Many gemological questions can still be answered with traditional methods. Yet there's no doubt that as treatments and synthetics improve, the real differences in the stones will diminish and become even more challenging to detect. "In light of new emerging treatments, the trade will have to accept that the old days of gemology using a loupe have long gone," says Krzemnicki. "And gemology nowadays has become a field in which scientific approaches are required to maintain the consumer confidence in the gemstones." ❍

Tomorrow's Tricorder

Most labs are focusing their efforts on perfecting the application of existing techniques to evolving gemological problems. Here are some emerging technologies to look for in the coming years.

TRACE ELEMENT CHEMISTRY

Determining the chemical composition of a gem remains at the heart of many gemological questions. Lore Kiefert of the American Gem Trade Association Gem Testing Center expects most analytical advances to focus on refining non-destructive methods for determining chemical composition. Advanced data interpretation, such as multivariant analysis, may improve the usefulness of LIBS, LA-ICP-MS, and SIMS in determining origin.

LUMINESCENCE

Photoluminescence techniques aid in detecting high pressure-high temperature (HPHT) treatment in diamonds. Both Emmanuel Fritsch of the Institut des Matériaux and Michael Krzemnicki of the SSEF Swiss Gemological Institute expect the techniques will also prove useful with colored stones. In the future, Fritsch suggests that excitation spectra, fluorescence, and time-resolved spectra may all help to distinguish natural from treated and synthetic gems.

IMAGING SPECTROSCOPY

Imaging spectroscopy techniques such as FTIR and Raman spectroscopy may one day provide a much more holistic view of gem chemistry, says Nicholas Del Re of the European Gemological Laboratory-USA. These techniques combine spectral, spatial, and radiometric data to generate a complete sampling of a gem. While Steve Lowry of Thermo Fisher Scientific Inc. agrees that hyper-spectral imaging may be more accessible for labs in the future, he says that the complexity and cost of the more sophisticated techniques may prohibit them from being used routinely.

STABLE ISOTOPE ANALYSIS

Despite promising results using oxygen isotope ratios to trace the origin of Colombian emeralds (see "Peering Into Emerald's Origins," July/August 2004), a detailed database of world gemstone isotope ratios is still sorely lacking. That means that, while isotopic analysis shows promise, until the industry develops a database of information from all or most of the world's gemstone mines with which to compare the results from a single stone, it remains a very expensive and largely academic technique.

FUTURE DIRECTIONS

Lowry predicts that accessibility, portability, miniaturization, increased sensitivity, and more efficient computer automation protocols will characterize the next generation of analytical instruments. For example, his company is working on a FTIR configuration intended specifically for gem analysis, and investigating the market potential for a low-cost, simple FTIR spectrometer that could be used by luxury jewelers to rapidly screen stones. Suspect stones could then be sent to advanced labs for further analysis.

Lowry thinks that much innovation will come from the

semiconductor and photovoltaic industries. He suggests that gemologists monitor advances in those industries when searching for new methods for the gem trade. — AS