THE CHALLENGES OF COLORED STONE AND DIAMOND ORIGIN DETERMINATION

Dr. James Shigley

Origin determination represents one of the most difficult aspects of gem identification for gem-testing laboratories, and one that is not well understood by many in the jewelry trade. The gem trade wants to be told, with complete accuracy, where their colored gemstones come from. Unfortunately, science cannot provide this capability. Thus, laboratories must rely on the experience of their most senior gemologists and a familiarity with gem materials from the different deposits to make origin determinations. This is the reason that these determinations are expert opinions – they are not facts. This presentation will go discuss the challenges of identifying gemstone origins, why those origins affect the price and value, and why these same criteria are not as critical for diamond evaluation.

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ORIGIN REPORTING FOR COLORED STONES

The main factors that determine the market value of a faceted gemstone are usually quoted as being rarity, size, and durability. However, a gem's beauty as well as its mystique or lore are also important. All of these factors add to the interest, desirability, and value of a particular gemstone. In addition, today's consumers often want to know where a gemstone comes from and how it was mined. The GIA Laboratory currently provides a country-of-origin determination on our gem identification reports for ruby, sapphire, emerald, copper-bearing (i.e. "Paraiba") tourmaline, red spinel, and alexandrite.

Origin determination represents one of the most difficult aspects of gem identification for gemological laboratories, and one that is not well understood by many. Gem dealers want to be consistently told with complete accuracy where their colored gemstones come from. Unfortunately, science cannot provide this capability. Thus, laboratories must rely on the experience of their most senior gemologists and scientists, and their familiarity with gem materials from the different deposits to make origin determinations. This is the reason that these origin conclusions are expert opinions based on a careful examination of the gemstone – they are not facts. To summarize, origin determination requires experienced scientific and technical staff, a range of analytical instrumentation for gem characterization, gemstone reference samples of known geographic origin for study, protocols for collecting and evaluating analytical data, and a searchable database of reference information. In addition, for more than a decade GIA researchers have conducted organized visits to localities in many countries to collect gem material of "know origin" for scientific study to support this laboratory report service.

The geological conditions of gem deposit formation produce the inclusions and other gemological properties that are often

characteristic of colored stones from particular localities. Different formation conditions result in colored stones from various deposits having different gemological features – this is the basic concept underlying origin reporting. Certain localities are known as historic and/or modern sources of higher-quality and more valuable colored gemstones, so a locality determination continues to be an important aspect of gemstone marketing and sales.

Origin reporting as a comment on gem identification reports began at the Gübelin Laboratory in Lucerne, Switzerland in the 1940s based on the pioneering work of the famous gemologist Eduard Gübelin. At that time, there were only a limited number of localities that produced, for example, high-quality rubies. Since the geological settings were different for these few deposits, origin determination was an easier process at that time; it was principally based on the microscopic examination of characteristic inclusions in the gemstone. In recent decades, the number of worldwide localities that produce high-value colored gemstones has dramatically increased, and origin determination has become a more challenging service provided by a number of gem-testing laboratories.

Origin determination for important colored gemstones involves the documentation of gemological properties, types of inclusions, chemical composition data, and in some cases the gem's visible absorption spectrum. While historically inclusion studies have been the basis of origin determination, chemical analysis of trace element impurities and features detected by spectroscopy techniques have today become essential components of this determination.

At the GIA Laboratory, colored gemstones submitted for origin determination are documented using a variety of scientific techniques. Inclusions and other visual features are examined and photographed using several photomicroscopes and various means of illumination. A spectrophotometer is used to record a visible spectrum which is directly related to a gemstone's color appearance. A technique called Raman spectroscopy allows for the recording of a type of spectrum created by the interaction of laser light with various chemical bonds to help identify a material (either the host gemstone or its mineral inclusions).

A quantitative chemical analysis of the gemstone can be determined by a mass spectrometry technique (abbreviated as LA-ICP-MS), where a nanosecond-pulsed laser beam focused on the surface of a polished gemstone is used to remove a tiny

amount of material from a volume about 50 micrometers (microns) wide and deep. The ablated particles are carried by a flowing gas into a very high-temperature plasma flame which ionizes all the components of the material. The resulting ions of all atomic species are separated and analyzed in the mass spectrometer down to very low concentrations (parts per million or less). Comparison of the results with a similar analysis of a standard material (such as a synthetic gemstone doped with desired elements at known concentrations) allows the calculation of the trace element chemistry of the gemstone. Information and results of all of these techniques provides an important basis for colored gemstone origin determination.

Most colored gemstones form in magmatic and metamorphic geological environments in the crust of the earth, which give rise to the features that can be diagnostic of their geographic origin. This determination is based on the idea that gemstones from different deposits will have different properties, which is not always the case. Similar deposits in different countries may produce gems with similar properties and, conversely, deposits in the same country may differ in their geology so their gems will be different. Given that geology is what determines a gemstone's characteristics from inclusions to trace elements, when the geology is very similar between distinct geographic deposits, this can lead to significant overlap in the data on gems from those deposits. The outcome is that a country-of-origin cannot be determined in all cases. When the data obtained from a gem sample are insufficient, a laboratory report is issued which states that the country-of-origin is "inconclusive".

It is important to recognize that origin reporting is an evolving process. Origin reports are based on evaluation at the time of the gem sample using the current state of knowledge and instrument technology. New localities, additional study of gems of known origin, data from studies of historical gem sources, and the introduction of new analytical techniques can all affect origin determination. The discovery of new colored stone sources is likely to continue.

Origin reports for colored gemstones are used and sometimes abused in the jewelry trade. Since gems from particular sources are more valued in the market, a favorable origin determination can make a huge difference in a gem's value. Even lower-quality gems from particular localities can have a market premium. Since there are no accepted standards for origin determination, various gem-testing laboratories can issue different origin conclusions on

the same gemstone based on their own criteria. While laboratories state that their reports represent expert opinions, members of the trade and the gem-buying public often consider them to be factual conclusions. Selling a valuable colored stone with conflicting origin reports from different laboratories forces the gem dealer or buyer to evaluate the reliability of an origin statement. Laboratories typically consider their origin-determination criteria to be proprietary information which would not be published, so it can be difficult to evaluate origin reports from different organizations. The Winter 2019 issue of GIA's professional journal Gems & Gemology provided a detailed explanation of the origin determination procedures for colored stones being used by the GIA Laboratory – this special issue can be viewed on the GIA website. It is important for laboratory clients to understand both what these reports represent and the limitations of this type of report service. We continue to believe that the quality of a colored gemstone is the most important factor in establishing its value – not the geographic origin.

Richard Liddicoat, GIA's former president, wrote an editorial entitled the "country of origin question" which appeared in the Winter 1990 issue of Gems & Gemology, in which he said:

"It is my personal belief that the sourcing of colored stones misleads the public and imposes an artificial price differential. Why should someone pay more for an inferior ruby from Burma? Gemstone purchases are made for the beauty of the stone – not for some artificial differentiation imposed by the trade or a laboratory. There is no question that diamond sales have been improved markedly by impartial grading. I feel that the sales of colored stones, likewise, could be improved materially by impartial laboratory grading of the elements of quality in such stones."

ORIGIN REPORTING FOR DIAMONDS

Some might ask if the geographic origin of a gem diamond can be determined in a similar way. Based on our present understanding, origin determination for diamonds is not possible. The value of a gem diamond is not dependent on its geographic origin, but on its quality factors (the 4 Cs) since many deposits produce high-quality diamonds. In comparison to colored stones, diamonds form deep in the earth under more homogeneous geologic conditions and, as a result, most display no visual or other characteristics distinctive of their geographic source.

Like colored gemstones, diamonds also contain trace amounts of

impurity chemical elements, but in concentrations many times lower that are difficult to measure. The carbon atom is quite small in size, and these atoms are strongly bonded together in the lattice structure of a diamond. The larger atoms of other elements (such as iron or nickel) are difficult to incorporate in the structure, which accounts for their low concentrations in diamond (up to one million times lower than in colored stones). Detecting trace elements uses an advanced scientific technique for a small "spot analysis" of the gemstone facet surface, with several spot locations chosen for analysis. In addition to their low concentration, trace elements in diamond are likely to be randomly distributed in the structure, so a spot analysis technique may or may not detect them. Any trace elements found would reflect the chemistry of the environment deep in the earth where diamonds form, and not the surface environment (the country) where they are found.

A significant additional challenge for origin reporting is the lack of a representative collection of gem diamonds from all primary and secondary deposits that would be available for scientific study to determine if origin determination is even possible. Claims by some of diamond origin determination should be viewed skeptically. Several recent scientific studies of a few localities and a limited number of diamonds have so far failed to demonstrate a geographically distinct signature based on trace elements.

The GIA Laboratory does offer a Diamond Origin Report in situations where we have been able to examine and document a rough diamond submitted from a particular mining locality. The rough diamond is then manufactured as a gemstone and the latter is resubmitted to us for examination. In instances where we can document specific evidence that the gemstone was fashioned from the original rough crystal, we will make a statement on our laboratory report on the cut stone of the country of origin as provided by the mining company.