

ORIGIN DETERMINATION FOR GEMSTONES : Possibilities, Restrictions, Reliability

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A definition of the term "origin" as used in gemmology should make the starting point of this paper. "Origin" should mean the geographical place where a gemstone deposit is situated. This is either the primary deposit in the parent rock or a secondary deposit where the gemstones have been transported to and accumulated after decomposition of the parent rock.

Since the terms Burma, Pailin, Kashmir have a geographical meaning, they should **not** be used to express a colour type of a gemstone. It is of common knowledge that a certain deposit produces different shades of colours, some of them may be found in other deposits, too.

The need of a certification of origin seems restricted for a few kind of gemstones and a small group of highly reputed deposits only. For many people the origin "Burma" (Myanmar respectively) may be commercially meaningful, whereas "Malawi" as an origin for a ruby does not create an increased interest.

In certain cases a cut gemstone can express its place of origin through its physical and chemical properties, by its inclusions and growth structure if these are clearly distinguishable from all other types. Thus these properties must be unique each by itself or in combination. The greater the number of individual and characteristic properties found in a certain stone, the more reliable is a determination of origin. Valuable characteristics should not only positively testify a certain origin but in the same time exclude other possibilities.

Consequently the expert for the deduction of the origin of a gemstone must be aware not only of the properties of that origin in question, but of the whole set of properties from all other similar material. Only the exclusive features, unique for a definite deposit are called diagnostic properties! Depending on the complexity of the formation of the gemstone crystals, the geological environment, the type and number of characteristics can be quite various.

The formation of a gemstone crystal requires some indispensable main conditions. The formation is also accompanied by a couple of side conditions. Both influence the resulting crystal in many respects. Some of these main and side conditions, causing the general and individual properties of a gemstone are the following :

Main and side conditions around a gemstone crystals formation

- availability of main constituent chemical elements, growth speed
- sort and amount of available trace elements, variation in their concentration and relative ratio
- transport process and transport medium involved
- type of energy source for the formation (intruding pegmatite, metamorphosis)
- partial pressure of free oxygen, redox situation
- cooling rate and pressure release during or after formation
- deformation history of parent rock and growing crystal
- protogenetic inclusions, reflecting parent rock
- syngenetic inclusions, reflecting transport medium and genetic type of formation

All these factors form the individual characteristics of a gemstone crystal, resulting in differences in:

Factors which may impress individual characteristics to gemstones

- size and shape of crystals, growth zoning
- colour, colour homogeneity, colour variation
- trace element mixture (including "invisible" trace elements)
- solid inclusions, twinning
- state of healed fissures, geometry and degree of restoring
- nature of fillings in negative crystal voids

What sort of characterising information can we collect from a cut gemstone (in respect of a determination of origin) ? The following characteristic features could be studied:

Characterist features in cut gemstones

Microscopic features : colour- and growth zoning relative to crystallography, colour inhomogeneity, twinning type, internal strain, observation of type and distribution of solid and fluid/gas inclusions, type of healing fissures.

Physical and optical features : determinations of specific gravity, refractive indices, double refraction, fluorescence behaviour, absorption spectroscopy (UV,VIS,IR), magnetic resonance spectroscopy.

Chemical features: main composition, trace element determination by EDS-XFA, amount or relative ratio of trace elements present (e.g. Ti, Fe, Cr, V, Ga), chemical analysis of inclusions by an electron beam instrument (scanning electron microscope, or electron microprobe) or Raman spectroscopy.

The determination of origin of a cut gemstone is thus a matter which requires a number of (expensive) instruments and a lot of experience in the use of these as well int the interpretation of the results. A collection of comparison stones (from all deposits, showing the variability within a population) for reference, files containing the analytical results measured over the years and a library with books and periodicals for old and new information are some of the most important requirements (compare list of references at the end of the article).

Some of the observed and registered characteristics are not restricted to one only deposit alone. But they may -in combination- be of diagnostic value. Those observations which are unique for a special deposit are the important diagnostic features in respect of an origin determination. For a successfull determination the following steps must be passed through:



Although experience, prudence, and honesty in the determination of origin on cut gemstones should base this gemmological task, the result still expresses the opinion of the analyst. His result reflects the best and most reliable possibilty on the backgroud of his comparison stone set and reference data. It seems clear that the education, scientific equipment and actual knowledge of the laboratory gemmologist are mayor points in the reliability of the origin determination. Not many laboratories have the necessary possibilites in terms of equipment and staff to work reproducable over years in this field. This is probably one reason why CIBJO is against the issue of origin certificates.

How can we get reliable basic knowledge on material from a definite origin ?

The most simple would be to collect it directly from the place of origin. In many cases this is not or no more possible, since that source is exhausted or not accessible. Therefore we must collect our reference material from a safe source like a museum, an old collection etc. Information on gemstone sources can also be obtained from books and publications. Many historical gemstone sources are treated in reference books. Geological maps give specific information on the type of deposit, scientific publications reveal the properties of the respective material, chemical analyses of the gemstones and their inclusions are published. All observations must be in agreement with the different facts known, e.g. trace elements with spectroscopy, inclusions with geology a.s.o. A selection of books and articles with valuable information for origin determination is given under "References" at the end of this paper.

From all this informations we gain a very complex view on a gemstone deposit and its production. The more material we investigate, the denser our network becomes. We are even able to add new observations to the formerly restricted set of information. Sharing and discussing of new information with collegue gemmologists with a high scientific standard brings even more safety into our determinations of origin. But it is prior to revise and recheck the

working fundamentals regularly by basic research and literature study of publications on new sources or techniques. Stagnation is dangerous.

Limitations in the determination of origin

As pointed out at the beginning, we use differences in properties as a means of discrimination. Properties which are repeated in stones from more than one source are not valued as diagnostic characteristics. But they can nevertheless be helpful to exclude other localities which do not possess these properties. As an example, a certain shade of blue does not prove a certain origin, nor does a misty turbidity. But the misty turbidity in combination with the absence of rutile needles points towards a group of possible origins and excludes some other possibilities of sapphire origins. Within the group of possible origins we may come to a definite source, if the stone itself expresses by further diagnostic characteristics its origin. It may e.g. exhibit a distinct path of the absorption curve, never seen in stones from an other place. At the same time it may show included crystals (identified by an electron beam instrument) which are typical for that only and definite source. These inclusions therefore exclude all other possibilities.

Origin determinations established by SSEF are not depending on one typical characteristic only, but at least on three independent diagnostic features preferably regarding inclusions, spectroscopy and trace element contents.

Testing possibilities for an identification are restricted if:

- properties observed do occur on several places, thus are not diagnostic,
- stones are free of diagnostic features,
- testing possibilities are reduced in set stones,
- knowledge are not broad enough,
- information is destroyed by heat treatment

If customers request for an indication of origin (and the stone does permit a reliable indication) SSEF is printing the origin on coloured stone reports. Our present position allows us to indicate origins of most of the rubies (Burma, East Africa, Thailand, Vietnam), Sapphires (Kashmir, Burma, Sri Lanka), Emerald (Colombia, Afghanistan, Pakistan, Brazil) and Alexandrite (Russia, Sri Lanka, Brazil). We are working on a scientific base, considering inclusions, growth zoning measurement, absorption spectrum (infrared, visible and ultraviolet part), chemical and further characteristics. Beside the well known gemmological instruments we are using research equipment like an X-ray fluorescence spectrometry device or a scanning electron microscope.

Sometimes gemstone deposits and therefore mining areas cross geographic borders, e.g. Kenya/Tanzania, Thailand/Cambodja. A larger producing country may also possess different areas in which the gemstones vary in their aspect, e.g. Sri Lanka, Vietnam, Brazil.

Certain people from the gem trade have too restricted opinions on the type of material coming from one definite source. In one source the stones can vary in size, colour and transparency quite considerably, a fact that we must keep in mind when associating a certain stone to a group. It is certainly not the overall aspect visible to the eye or the hand lens by which the origin of a stone can be determined. A possible origin is on the contrary proved by the most careful investigation of all properties by an experienced gemmologist using modern scientific equipment. And if there is any doubt or ambiguity, an independent and serious scientist would not give a definite result. Lab people would greatly estimate if their customers could accept this ethic policy, especially in a case where our result does not confirm his expectation. Sometimes a laboratory cannot issue a certificate of origin or it turns out different to what a client hoped it to be. In most cases this is due to the characteristics of the stone which are not diagnostic in respect of an origine determination.

I hope to have illustrated by this paper the possibilities and difficulties in regard of an origin determination of cut gemstones. The techniques and the philosophy which governs our work at SSEF Swiss Gemmological Institute regarding the elaboration of colour gemstone reports and, as a supplement on request, the indication of origin, may be similar in other advanced gemmological laboratories. Nevertheless, small differences in the application of methods or a varying set of reference data could sometimes lead to different results, thus another opinion, where a definite gemstone could originate from.

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