

## RELIABILITY OF ORIGIN DETERMINATIONS FOR GEMSTONES

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Definition: Origin = **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 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.

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** requires some indispensable main conditions, the formation is also accompanied by a couple of side conditions, which influence both, the resulting crystal in many relations. Some of these main and minor **conditions**, causing the general and individual properties are the following :

- availability of main constituent chemical elements, growth speed
- sort and amount of available trace elements, variation in concentration
- transport process and transport medium involved
- type of energy source for the formation (intruding pegmatite, metamorphosis)
- pressure of free oxygen
- cooling rate and pressure release during/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:

- 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) ?

### Characteristic features

#### Microscopic investigation

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.

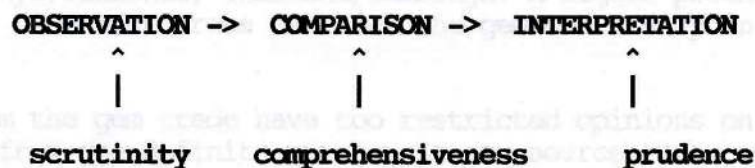
#### Physical and optical determinations

specific gravity, refractive indices, double refraction, fluorescence behaviour, absorption spectroscopy (UV,VIS,IR), spin resonance spectroscopy,

#### Chemical determination

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 electron beam instruments (scanning electron microscope SEM, electron microprobe)

Some of the observed and collected characteristics are **not** restricted to a certain deposit. 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 successful determination the following steps must be passed through:



### How can we get reliable basic knowledge of 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.



From all this informations we gain a very complex view of 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 colleague 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 I have 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.

Our possibilities are restricted if:

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

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

Many persons 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 which decides the origin of a stone. 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. I would greatly estimate if our present or future customers could accept this ethic policy, especially in a case where our result does not confirm your expectation. Sometimes we cannot give a certificate of origin or it turns out different to what you hoped it to be.

I hope to have illustrated by this talk the possibilities, techniques and the philosophy which governs our work at **SSEF** regarding the elaboration of colour gemstone reports and, as a supplement, the indication of origin.



We are using two types of expressions when we give an indication of origin. If the stone shows commonly known and widely accepted diagnostic features, we use the following formulation:

According to your request for an indication of origin, we confirm that the ruby described in the Gemstone Report mentioned above, shows inclusions as well as physical and chemical properties which, based on present gemmological knowledge are characteristic of a ruby from Burma.

In the case that a stone contains, among commonly accepted characteristic features, those recently observed and certified in our laboratory, but not yet published and accepted generally, we use the following expression:

According to your request for an indication of origin, we confirm that the sapphire described in the Gemstone Report mentioned above, shows inclusions as well as physical and chemical properties, which, in our opinion, are characteristic of a sapphire from Kashmir.

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In certain cases a cut gemstone can signal its place of origin through its physical and chemical properties, by its inclusions and growth structure. It comes as clearly distinguishable from all other types. Even these properties may be unique only 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 characters should not only positively testify a certain origin but in the same time exclude other possibilities.

Consequently the expert for the detection 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 to the complexity of the formation of the gemstone crystals, the geological environment, the type and number of characteristics can be quite various.

The formation process and conditions are also dependent by a cover of side conditions, which influence both the resulting crystal in any relation. Some of them are: temperature, pressure, oxygen, and other factors. These are the general and individual properties are following:

- availability of main constituent chemical elements, growth speed
- sort and amount of available trace elements, variable concentration
- physical and chemical treatment and secondary changes
- type of energy for the formation (intrusive pegmatite, metamorphic, etc.)
- pressure of free oxygen
- cooling rate and pressure released during/after formation
- deformation history of parent rock and growing crystal
- protogenetic inclusions, reflecting parent rock
- syngenetic inclusions, reflecting transport medium and general type of formation