A European Gemmologist's thoughts on Jadeite Jade

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作者對硬玉玉的三個主要題綱作出研究及分析：

為何硬玉玉不是通透明的？

為何硬玉玉是綠色的？

為何硬玉玉的某些寶石數據常數不是一成不變的？

Introduction

The topic of jadeite jade has been exemplarily treated in the new book by Cecilia Lam (Lam, 2005), but the last word will probably never be spoken on this intriguing stone. So this short paper comes in the form of a report on three major questions that may yet arise when one reflects about jadeite as a member of the gemstone family:

Why is jade not transparent?

Why is jade green? And

Why are certain "constants" not always constant?

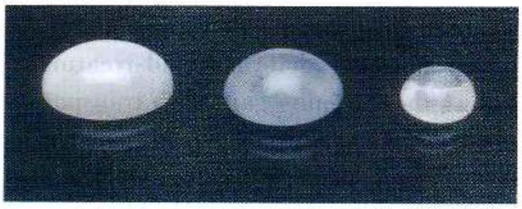

Fig. 1 Two polycrystalline (left) and one single crystal (right) cabochons of colourless jadeite. The different degrees of transparency reflect the amount and tightness of the polycrystalline material. The unique single crystal stone seen on the right is fully transparent. Courtesy S.T. Wu, Kaoshiung, Taiwan. Photo © H.A. Hänni

Degree of transparency

Most gemstones are transparent monocrystals and end up as facetted stones. Semitransparent or translucent or opaque gem material is cut as cabochons. Jadeite can be translucent or opaque due to its polycrystalline nature and grain size. A piece of jadeite consists of a blocky mosaic of thousands of crystal grains. Their structure is described as fibrous to granular and from fine- to coarse-grained. The individual crystals may be perfectly clear or of an *intransparent* nature, the latter inhibiting a transparent or even translucent gemstone. Their grain boundaries, particularly when widened by weathering, inhibit a straight light path and diffuse the light in a stone. (Fig. 2 & 3) Most often the narrow open-grain boundaries are filled with secondary minerals, rusty stuff that spoils what might otherwise have been nice quality material. We are all aware of the processes that make use of the rather porous jadeite for acid-treatment. Filling these minute gaps with transparent media (wax, epoxy etc.) improves transparency. After cleaning out the deposited secondary minerals (iron oxide) the gaps are filled with colourless material. This treatment results in B-jade or, given dyed material, in C-Jade.

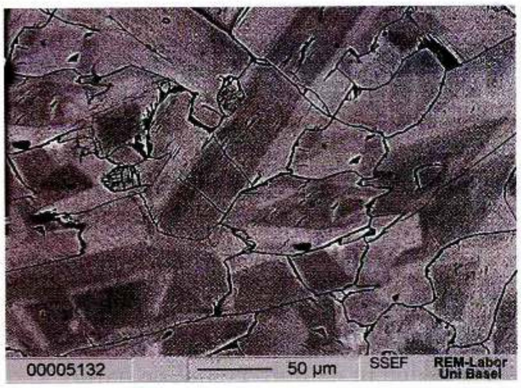

Fig. 2 Scanning electron-microscope picture of a polished surface of weathered jadeite. Each jadeite grain is surrounded by a narrow gap at the grain boundary. In B-jade and C-jade these openings enable an introduction of organic filler like epoxy or dye. The tiny openings are responsible for the frequently poor polish of B-jade. Photo M. Düggelin, ZLM, University of Basel.

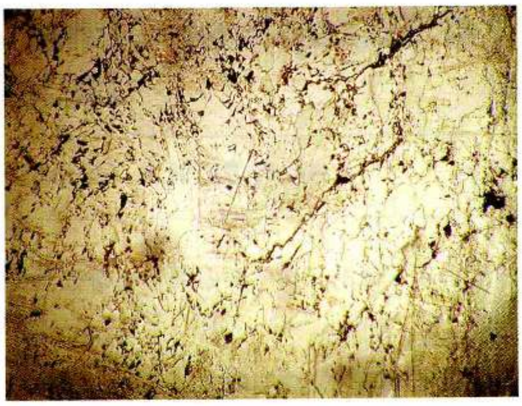

Fig. 3 Surface structure of a B-jade. The open grain boundaries are visible with a loupe and are characteristic for treated jadeite. Photo © H.A. Hänni

From the mineral to the rock

The polycrystalline structure of Jadeite Jade can also bear foreign minerals, and so the way is open for the mono-mineral to become a rock i.e. an association of different minerals. Sometimes black grains of what is presumably chromite are encountered in green jadeite. We can see these as relics from the chromium source that supplied the chromophore elements. When the presence of foreign minerals becomes substantial, we have what is no longer a mineral but a rock. This is the case with the gemstone maw sit sit, a material that is closely related to jadeite. It occurs in the classic jadeite producing area of Burma (Namshawa, 10 km north of Lonkin) and comprises a number of other minerals including chromite, kosmochlore, jadeite, Cr-jadeite, Cr-eckermanite, symplectite, zeolithes, albite and serpentine. Its densities vary between 2.5 and 3.2 g/cm^3, depending on the variable mixture of minerals.

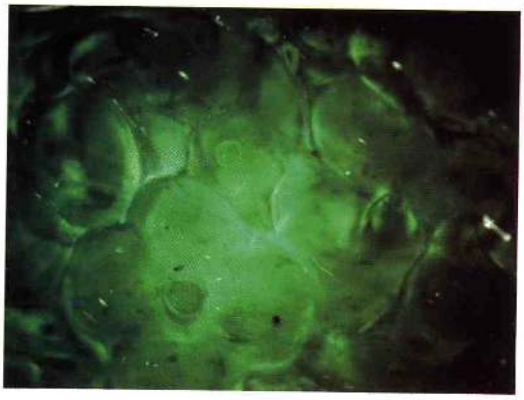

Fig. 4 Carved jadeite with small black inclusions of a chromian spinel mineral, probably chromite. Photo © H.A. Hänni

Fig. 5 A piece of Maw-Sit-Sit, a jade-related rock from Myanmar (Burma). The material contains at least eight different minerals and its visual aspect may change considerably according to the ratio of composing minerals. Photo © H.A. Hänni

Colouration by Cr admixture

While ideal minerals possess a simple chemical formula to express their composition (e.g. Jadeite $NaAlSi_2O_6$) actual gemstones usually contain admixtures sometimes as traces or which can also be considerable. Generally small amounts of the foreign elements which are responsible for colouration are covered by the term "trace elements". A trace element is thus not a specific element, but any element present at less than 0.3%. When the level is higher, up to 5%, we use the term "minor element". Major constituents of a chemical formula are "main elements". It is interesting to observe the role of chromium in jadeite. Depending on the amount contained in the material, it may be a trace element, a minor element or a main constituent. Let me explain this in more detail. We generally say that a nice green jadeite owes its colour to traces of chromium, characteristically about 0.5 percent of the weight. When higher amounts of Cr are present, the colour changes, to dark green or even black. Together with this increase of Cr, certain "constants" such as the RI and SG increase in value. And the question may arise: just how much Cr can a jadeite digest?

Fig. 6 An engraved piece of semi-transparent jadeite with an estimated content of 0.6 wt% Cr_2O_3 or a kosmochlore content of approx. 1.6 mole %. Photo © H.A. Hänni

A mixed crystal series situation

Here we must discuss a concept that is helpful in the science of mineralogy. The concept of a "*solid solution*" between two well-defined end members is used in mineralogy to describe mixtures between so-called *end members*. These admixtures refer to ions in the crystal lattice, rather than to mineral grains. The crystal lattice is a geometrically defined pattern of order for constituents of the mineral composition. Certain identical positions in the lattice may be occupied by differing ions of similar size and the same charge.

Since aluminium, Al, and chromium, Cr, have a similar ionic size and the same 3^+ charge they are interchangeable in the crystal lattice. And because a mineral grain is composed of millions of times the mineral formula, there are frequent opportunities for the 3^+ lattice site to be occupied by Cr instead of Al. It is just the availability of Cr during crystallisation that governs the extent of replacement. And this situation exactly depicts the solid solution scenario between the end members, jadeite $NaAlSi_3O_6$ and kosmochlore $NaCrSi_3O_6$. The middle point of this series is represented by the formula Na $(Al_{0.5}\ Cr_{0.5})\ Si_2O_6$. This two component mixed crystal situation is also applicable to the pyrope-almandine series of garnet, where the well-known rhodolites are represented with a pyrope 85/almandine 15 ratio.

With jadeite we are faced with two main compositions that form chemical admixtures: kosmochlore and omphacite; related minerals that go into solid solution with jadeite. While kosmochlore covers the Cr admixture in real jadeite, omphacite covers the Ca, Mg and Fe encountered in jadeite.

We can now discuss how much of a foreign component of either kosmochlore or omphacite is allowed in a jadeite before it is no longer regarded as jade. A solution is proposed by the new *Hong Kong Standard of Fei Cui Jade* that gives upper limit values for the RI as 1.688 and for the SG as 3.40. The discussion here is still related to a monomineralic and polycrystalline mixture of members of the Jadeite-Kosmochlore series. The natural Fei Cui jade may, of course, also contain foreign mineral grains such as chromite that move the SG to higher values.

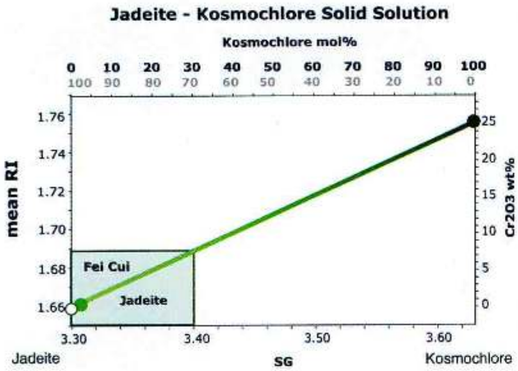

Fig. 7 Simplified graph showing the relationship of density and mean refractive index in the two-component systems of jadeite and kosmochlore. The curves for SG and RI show a linear relationship with the degree of substitution. A solid solution of jadeite with omphacite would have a similar increasing effect to that of the kosmochlore admixture. The green field shows the data that include Fei Cui jade. Photo © H.A. Hänni

Conclusion

Jadeite Jade is usually a monomineralic rock or a polycrystalline mineral. It can, however, change its familiar status either by mixing in a solid solution to form kosmochlore and omphacite, or by blending with other minerals where it may even find itself to be a minor component, as in maw-sit-sit. With this behaviour jadeite and its related materials are providing a great education for gemmologists; broadening our views. In Hong Kong the Gemmological Association has devoted considerable time and thought to the matter in order to provide guidelines for the jade trade with regard to terminology and testing standards. The result is a publication well worth having on ones bookshelf: *Standard Methods for Testing Fei Cui (Jadeite Jade) for Hong Kong.*

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