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GEMMOLOGY

AN OIL WELL IN YOUR GARDEN?

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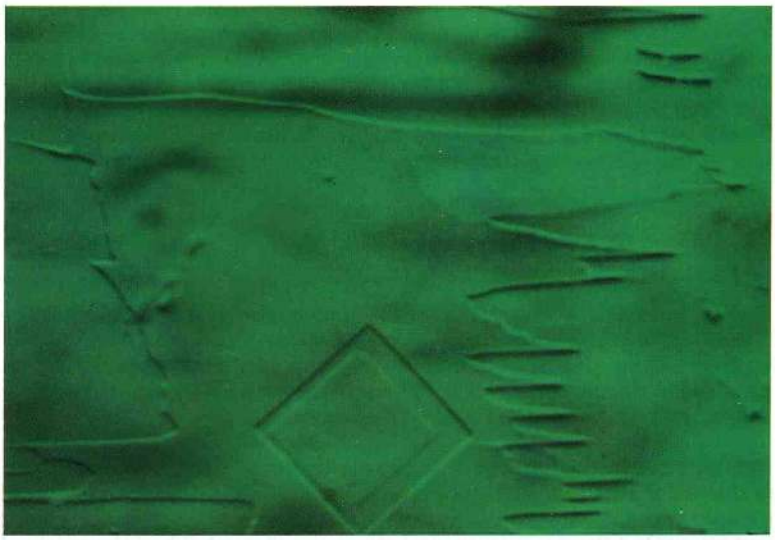

This paper does not wish to deal with the luck of a Texan property owner, but rather to share my experience in the gemmological laboratory. The article could just as well be titled: What many people do not yet know about oiling emeralds, and others at times tend to forget.

"Gemmosophic" literature likes to use the French term "jardin" (Engl.: garden) for typical, veil-like inclusions visible to the naked eye. These internal structures, resembling leaves and tendrils, are commonly classified as healed fissures, but often also as open cracks. The latter are usually considered to be negative properties.

Introduction

The mineral beryl is formed under differing geological conditions, which can affect size, colour and purity of the crystals. The pegmatitic to pneumatolytic formations of beryl (e.g. aquamarine, golden beryl, heliodor, morganite, goshenite) crystallise from a fluid-rich melt. The products of this slow and quiet process are often large, clear crystals generally poor in inclusions.
Metamorphic and hydrothermally-formed emeralds are seldom produced under such calm and constant conditions, as dynamic forces were in operation, resulting in the presence of foreign crystal inclusions and fissures at various stages of healing (Fig. 1). Crystal chemistry-invoked stress can be the cause of these cracks or fissures. Changes in chemical and physical conditions during crystal growth can also result in the development of stress and strains. These may be relieved by the formation of cracks, and if this occurs during crystal growth, simultaneous partial healing can take place. The serrated cavities in Colombian emeralds with their typical two- or three-phase fillings are the result of such an event. These flat cavities lie on the earlier crack planes, which have now mostly healed. If the cavities are sufficiently large or dense, they can show the total extension of the earlier fissure (Fig. 2).

Fig. 1 Spiral-shaped tension fissure, running parallel to the c-axis in a Colombian emerald. The upper part of the spiral healed naturally and is now barely indicated by tiny voids. The lower part did not undergo a natural healing process and still shows its reflecting characteristic.

Fig. 2 Angular flat cavities on a former fissure plane in a Colombian emerald. During the natural healing process, fluid was enclosed which in general separated into an aqueous solution, a salt crystal and a vapour bubble (so called three-phase inclusions).

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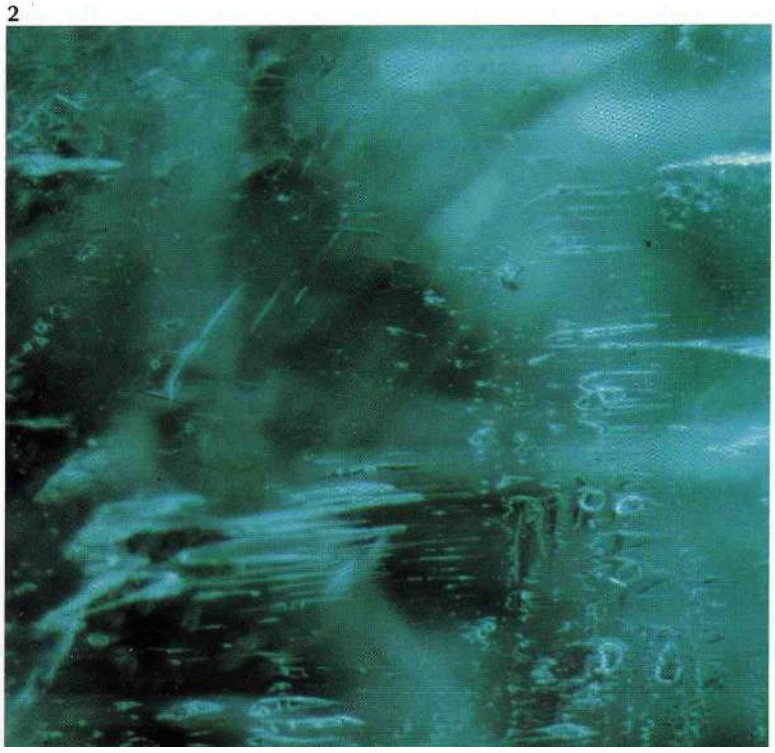


During a disturbed crystallisation of an emerald, the formation and subsequent healing of fissures can take place repeatedly. The various generations of cavities containing crystals or gas/liquid fillings can be distinguished under the microscope.

Cracks in emeralds, which are formed *after* the last phase of crystal growth, have no chance of being healed by natural processes (Fig. 3). If they extend to the surface of a cut stone, their conspicuous nature can be artificially lessened. Still, why are such fine cracks so visible? The explanation is that they represent an obstacle to light travelling through the stone, and thus behave like small mirrors. Total reflection can result when the stone is viewed from various directions.

In a facetted stone, light is reflected outwards after multiple internal reflection between several facets. Along its path the light is absorbed selectively and in a manner characteristic of emeralds, i.e. it shows colour. The shorter the distance the light travels, the weaker the colour. Should the light path be interrupted by a crack, the length of the "journey" becomes shorter and the colour weaker. Reflecting cracks are therefore conspicuously light to the observer (or dark, if viewed from behind the "mirror").

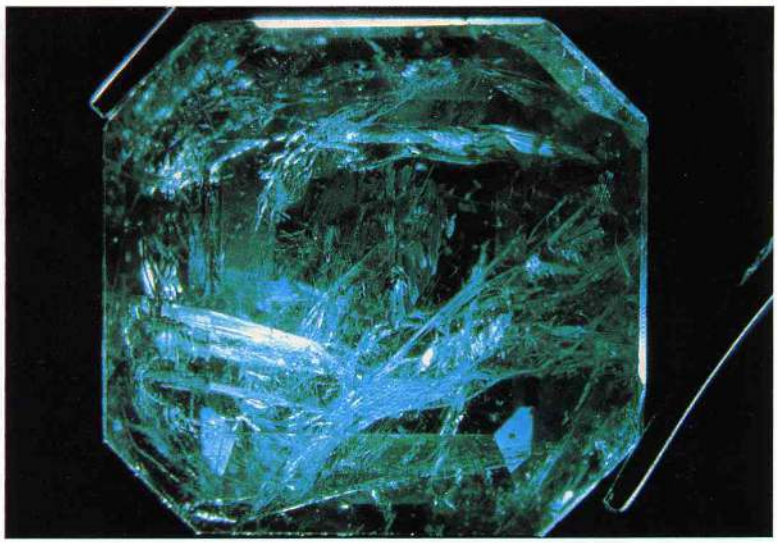
The Treatment of Cracks

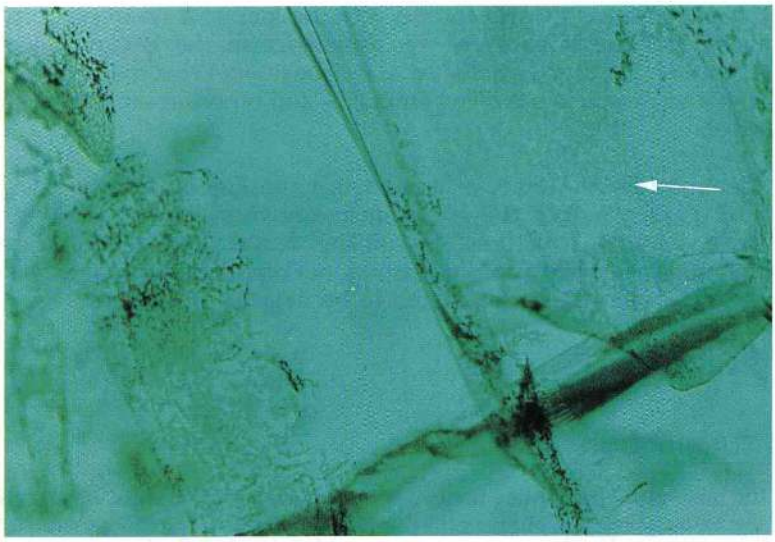
Fissures in emeralds originally contain vapour, gas or are under vaccum. These media possess refractive indices considerably lower than that of emerald. These cracks are therefore very capable of reflecting light. This capability would be considerably reduced if they were filled with a substance with a similar refractive index to that of emerald.

Now we have come to the heart of the matter, namely the ways and means of treating cracks so that they become invisible, or at least reduced in their conspicuousness. Most emeralds of usable size unfortunately contain cracks and fissures but these can be treated. A very small number have been found to be free of fissures. Colombian emeralds are considered to be particularly superior in all respects. Their transparency and colour are highly esteemed, although (like in all deposits) all grades of quality are produced. Quality distribution is therefore also pyramidal in the Colombian material and top quality is a great rarity. The numerous stress fractures and cavities in the big majority stand in stark contrast to their enormous prestige and reputation. Therefore, to fulfill the trade expectations these stones undergo a cosmetic face-lift.

Crack Fillings

For decades, fillings of oils and resins with a viscosity low enough to penetrate as deeply as possible into the cracks have been used (e.g. cedar oil, Canada balsam etc.). The lower the viscosity of the medium, the more complete is the penetration of the fissures. Warming the liquid used lowers its viscosity even further and for this reason both the stone and the liquid are warmed. Sometimes even vacuum techniques are used to improve the results. The range of fillings encompasses numerous substances: apart from the more or less volatile substances such as oils, fats and resins, there are more stable compounds such as synthetic resin polymers today. The latter possess the advantage of a solid union with the stone, resulting in a lasting improvement in appearance, not usually possible with the volatile compounds used traditionally which are soluble in soaps, detergents and solvents, and can dry out. Owners of emeralds are thus often confronted with a "before-and-after" situation, not particularly amusing to the person concerned!





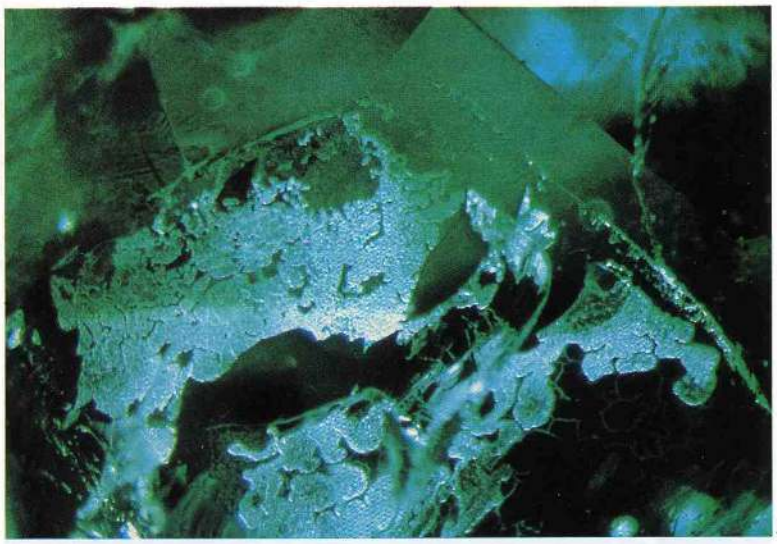
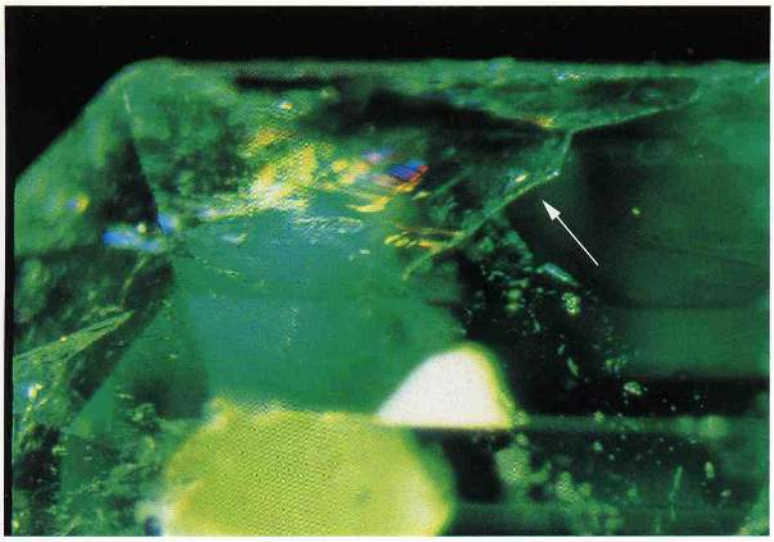


Fig. 3 Colombian emerald with numerous open, heavily reflecting fissures. Before this picture was taken, oil was cleaned from this stone in an acetone bath.

Fig. 4 Treated fissure in an emerald. Dendrite-like patterns are visible with the dark remainders of cutting dust. They also are present deeper in the crack (arrowed portion).

Fig. 5 Extensive "lakes" of air in an oil-filled fissure in emerald. This pattern forms when the oil dries out.



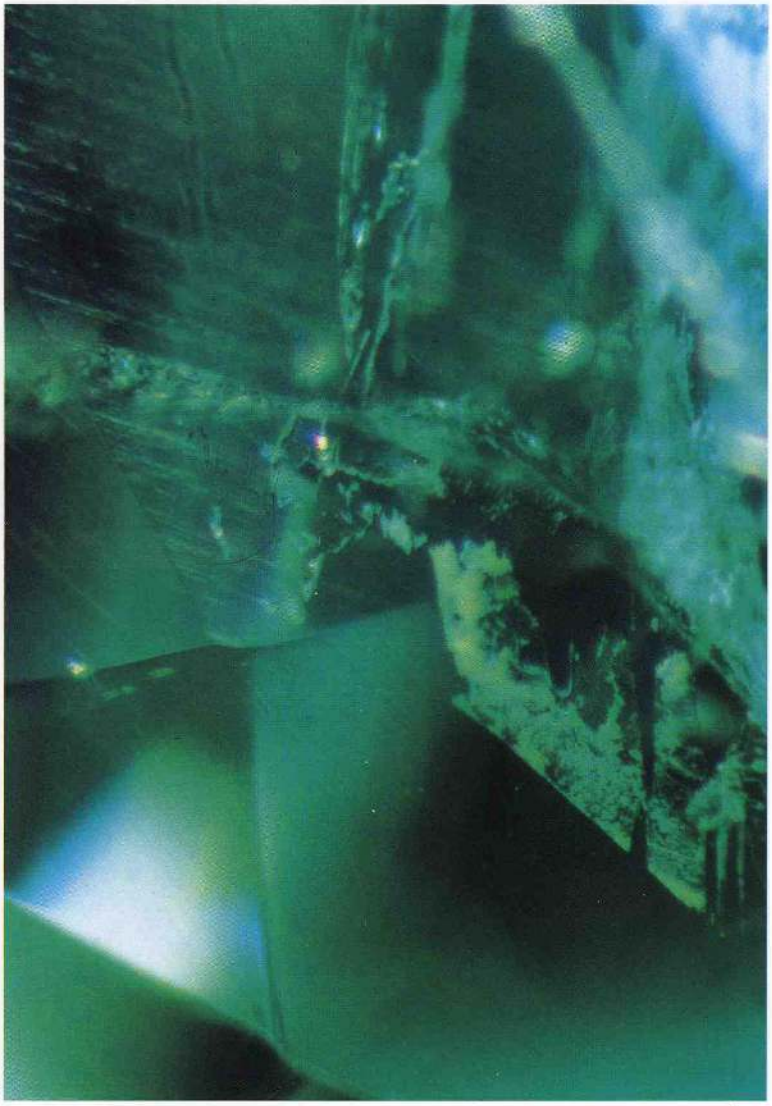


Fig. 6 Fissure with a filling of Canada balsam, a natural resin. The fissure shows interference colours, the arrow indicates the opening to the surface.

Fig. 7 Open fracture, covered with remainders of polishing powder (chromium oxide).

Recognising Treated Emeralds

The recognition of volatile crack fillings is relatively easy using optical methods. A microscope equipped with dark field illumination is used without immersion. Immersion liquids would penetrate cracks and, due to their high refractive index, would make identification well nigh impossible! Under the microscope, oil-filled fissures can usually be recognised by the presence of gas dendrites or amoeba-shaped flat air bubbles (Figs. 4 + 5). These can be formed by infiltration of air or by vapour emanating from the filling medium. The volatile portions in resins often form tree-like gas dendrites in the depth of the fissures (Fig. 6). In the cracks near to the surface of the stone, remnants of polishing powder (e.g. chromium oxide) can occasionally be detected. This has a greenish-yellow colour and produces a granular effect (Fig. 7). The volatile crack fillings often fluoresce under ultra-violet light.

Oil Fillings can easily be removed using solvents and heat. Most oil-filled cracks in the surface regions of the stone are cleaned in a bath of acetone, hexane or $CHCl_4$. The deeper cavities in the stone are cleaned by prolonged use of warm solvents or by dipping the solvent vessel and stone in an ultrasonic bath. The treatment will only remove oil from existing cracks, which then become invisible after treatment. The mechanical stress imposed on emerald by ultrasonic waves is less than that suffered by the stone through blasting at the mine, sawing, gluing grinding or polishing. Potential cracks most probably were formed during these previous treatments.

Cavities filled with **paraffin** or semi-solid **sperm whale oil** can be recognised as granular whitish planes during dark field observation under the microscope (Fig. 8). Should the cavities filled with oils or paraffin be heated, then the filling will expand and the stone will begin to "sweat" from the cracks. This oil can be recovered on a piece of tissue paper, and its colour examined (colourless or coloured).

Artificial Resin-filled Cracks. These filled cracks in emeralds are also typical. The crack planes are recognisable as lightly rough-structured planes with shrinkage fissures. Polymerisation of the resin is coupled with a volume reduction of the fissure filling. Due to this, the skin which closes the fissure will exhibit dendrite – like shrinkage structures (Fig. 9). If filled pits or cavities reach the surface, the filling medium can be tested with a hot needle. Smoke and odour emerging indicate the presence of foreign matter!
Fissure fillings composed of organic substances as above can be precisely analysed by infra-red spectro-photometric methods. Volatile and semi-solid fillings are dissolved in solvents, and the residues analysed. Synthetic resin polymers can be determined for example, using IR-methods, too.
Synthetic hydrothermal healing of fissures would represent the most perfect way of restoring stones, as it is lasting and inconspicuous.

We can now **review** what we call «oiled» emeralds more critically. Liquid oil is now being replaced by more enduring materials such as semi-solid and solid fillings. Through treatment with synthetic resins, the desired condition is lasting and there is no return to previous state. The foreign matter, on the other hand, cannot be removed for a critical appraisal of the "naked" stone. Occasionally the use of green oil is considered to be particularly objectionable, although the delicacy of the fissures does not result in marked colour enhancement. The replacement of air in the fissure alone results in a deepening of the colour through an increase in the length of the light path (and thus in absorption). Filling larger cavities with green oil or coloured artificial resins, on the other hand, has a very strong influence on colour. Cavities so-filled usually contain disproportionally large bubbles exhibiting, in part, unusual shapes (Fig. 10).

Treatment Designation

The rules of nomenclature of the CIBJO do not demand specific disclosure of oiled emeralds, as long as the oil used is colourless. Emeralds with green oil must be termed "treated emeralds" (§ 5), as must stones with artificial resin-filled cracks. At present, new and more precise CIBJO regulations are being drawn up. The subject of oiling emeralds is similarly discussed within ICA.

An important point in respect of a notification of the treatments seems to be the **extent** of the effect caused by the treatment. This, of course, is extremely difficult to quantify.

The fact that an oil-treated emerald does not have to be designated a treated stone leads to continual conflicts, as such a stone obviously has been treated. The beneficial effect of treatment can disappear rapidly, again revealing the unattractive fissures, and the owner will feel that he has been defrauded. The reason for this is that he has no idea of any previous treatment history of the stone and is taken unawares by the change in appearance of his possession. One would expect all members of the gem trade to be well informed about treated stones, but this is by no means the case! Even experienced gem dealers and jewellers often believe that their emeralds are exceptional, contain no cracks and therefore do not contain fillings. In order to of clarify and defuse the situation of oiled emeralds, open and candid information is the order of the day, right down to the customer. Volatile fissure fillings in emeralds belonging to a non-informed owner represent a potentionally **dangerous breach of trust** for the whole gemstone trade.

"The oiling of emeralds is standard practice and has been so for decades. If you so wish, we can undertake the re-treatment of your stone. The emerald in question would cost as much with unfilled fissures as with oil-treated ones". These are the points that are essential, their absence leading time and time again to conflict.

Recommendation

Always assume that all emeralds contain treated fissures, unless you are totally convinced – by your own examination – that the contrary is true for a specific stone. Furthermore, assume that your partner opposite you has no idea of the standard practice of filling cracks, when discussing a particular emerald. "How am I going to inform my customer?" is now your delicate problem. Gain respect by your frankness and knowledge. In future you will be respected as an expert.

Acknowledgements

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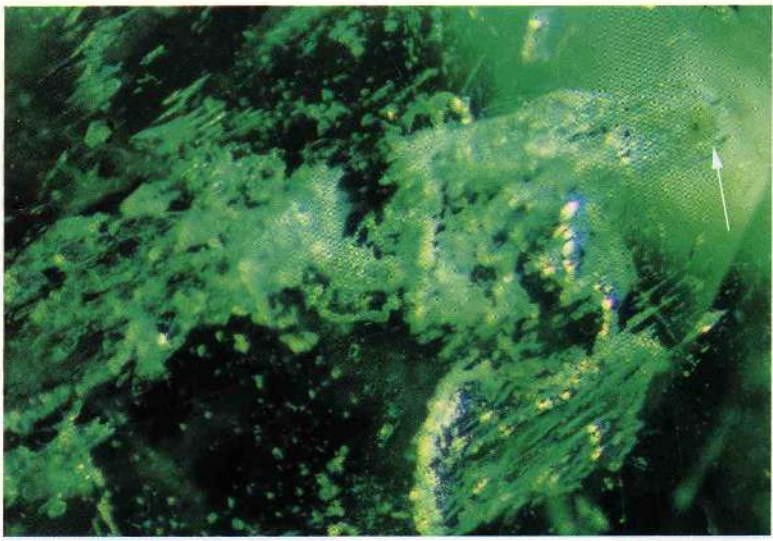

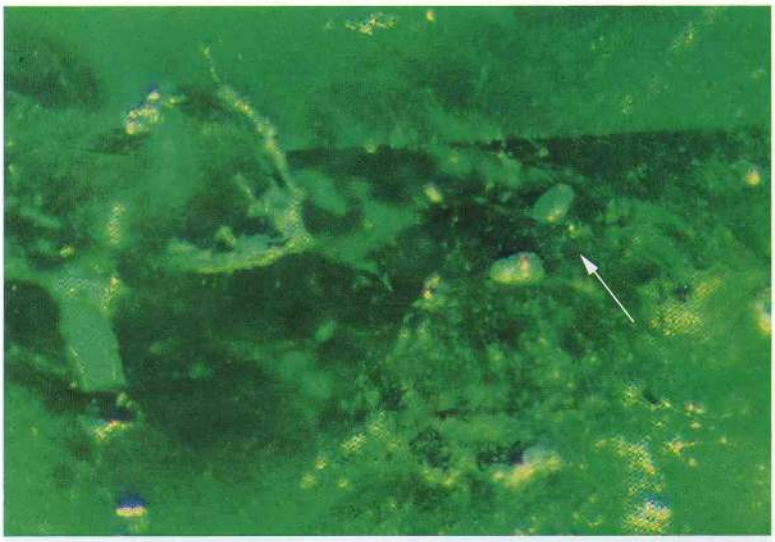

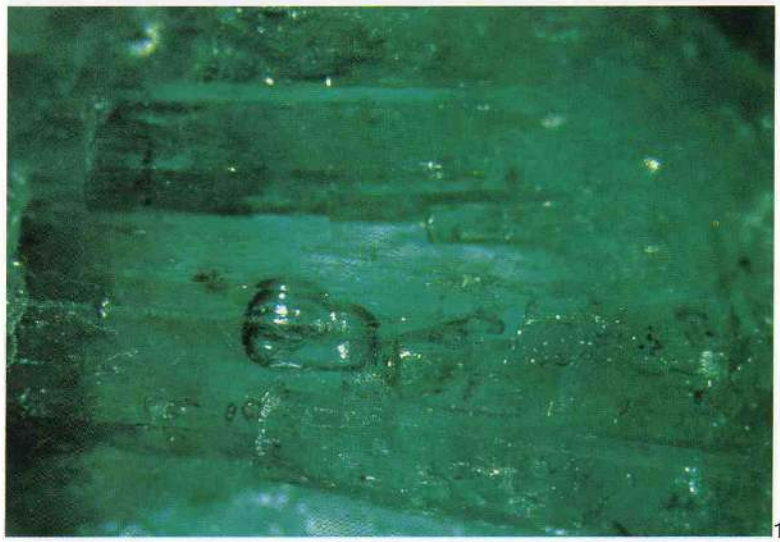

Fig. 8 Filled voids in emerald. The filling consists of sperm whale oil. The opening of the void is indicated with an arrow.

Fig. 9 Emerald with fissures and voids filled with artificial resin (Araldite). Two bubbles in the resin are marked. Their spherical shape has slightly changed by shrinkage due to polymerisation.

Fig. 10 Oil filling in a rough emerald cluster. The oil has a bluish-green coloration. The bubble measures about 0.4 mm in length.

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