

THE ORIGIN OF HEALING FISSURES IN GEMSTONES

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HEALING fissures as inclusions in gemstones are well known and have often been described. In spite of this, the question of their origin has not yet been answered. A most valuable hint can be found in papers published by American authors about liquid inclusions in some minerals of the pegmatite series. Here, the aim of numerous investigations was to find out whether or not the liquid inclusions could be used as a "geologic thermometer." In this sense researches have been made to prove whether those particular inclusions could supply the desired information about the temperature at which the minerals of the pegmatites, and consequently the pegmatites of certain localities itself, have been formed.

As some of the pegmatite minerals belong to the best known gemstones and as, on the other hand, a great number of liquid inclusions are combined with healing fissures within these stones, the results which were found are important enough to be quoted.

E. N. Cameron, R. B. Rowe, and P. L. Weis¹ give the following explanation :

"The implication is, that the secondary inclusions (the 'healed fractures') are formed from solutions of the same general composition as the apparently primary (liquid) inclusions and probably they are developed only a short time after the host crystals ; *i.e. within the period of pegmatite formation.*"*

A confirmation of these observations is found by P. L. Weis.² He obtained the same results during his studies of the fluid inclusions in beryl, quartz, tourmaline, and spodumene.

The observations of these authors indicate that healing fissures are mostly originated during the growth of the host crystal. This point of view could be confirmed in many cases. In other cases it seemed to be likely that the formation of healing fissures took place after the growing period of the host crystal, *i.e.* during a later time, when the crystal was still *in situ* within the mother rock, or weathered out from it and embedded in a second or third deposit. For these

* The terms in parentheses and the italics have been added for the purpose of this article.

reasons it is useful to distinguish between “ early ” (or “ subsequent ” instead of secondary) and “ late ” healing fissures, as both types can be easily recognized. Such a differentiation could also avoid the more common term “ secondary ” healing fissures, which has already caused some misunderstanding.

The proposed classification has the following meaning : “ Early ” (or subsequent) healing fissures originated during the growth of the host crystal ; they are of syngenetic origin. “ Late ” healing fissures are formed after the growth of the host crystal ended ; they are of epigenetic origin.

During the study of a great number of healing fissures in numerous gemstones it was observed that the main reason for their “ early ” or syngenetic origin was undoubtedly a *great growing rate* of the brittle host crystal. It seems to be obvious that a rapid growth of a crystal, practically in all cases, is combined with the effect of a strain or a stress, which in its turn produces cracks in preferred directions or at random. It is also not difficult to understand that such syngenetic fissures immediately after their formation had to undergo a healing procedure, which lasted so long as the host crystal itself could continue to grow. Preferred directions are those of the cleavage planes of the including crystal, and these are indeed more often than expected the places of healed or partly healed cracks.

Another cause which could be found, is the presence of primary crystal inclusions. Such a foreign material could produce cleavage cracks (early) or tension fractures (early and late), and both kinds healed according to the ruling circumstances.

Finally a mere shear tension, which could easily occur for different reasons, has been the cause of cracks which subsequently healed into different kinds. It has been found that these particular healing fissures are formed either by a rapid growth of the host crystal (early) or that they are favoured by the existence of a cleavage (early and late), or by other reasons of geologic events (mostly late).

In order to obtain a general view of the complex features of the healing fissures and the different causes of their origin, the following scheme is suggested :

HEALING FISSURES IN GEMSTONES

<i>Originated by</i>	<i>Examples</i>	<i>Time of Origin</i>
I. Rapid growth of the host crystal	Synth. emerald, pegmatite minerals like quartz, beryl, topaz, tourmaline, etc.	early
II. Incipient cleavage	Topaz, fluorite, scapolite, zircon	early and late
III. Primary crystal inclusions which cause (a) cleavage cracks (b) tension cracks	Snow-flake inclusions in aquamarine Tourmaline, aquamarine, garnet	early early and late
IV. Shear tension which causes tension cracks in the host crystal A shear tension can arise by (I) and it can cause (II)	Aquamarine, garnet, zircon, and numerous others	early (and late)

Convincing examples for a rapid growth of a crystal causing healing fissures were found by the crystallization of ammonia-alum ($\text{Al}(\text{NH}_4)(\text{SO}_4)_2 \cdot 12 \text{H}_2\text{O}$). In applying a greater growing rate, clusters of very small alum crystals are deposited on an already present crystal plane. As can be seen in Fig. 1, tiny and unoriented crystals form a stripe, running from left to right. It caused within the bearing crystal, fissures in different directions, from which fissures one happened to be nearly parallel to the growing plane (111) of the host crystal, so that it can easily be observed.

In another case (Fig. 2), such a smaller cluster produced cracks in different directions which had already started to heal. This early healing process could be accomplished by bringing the host crystal back in the mother-liquor for a longer time (Figs. 3-5).

A great growing rate is also most probably responsible for the cause of those curious veil-like twisted "feathers" which are so typical of synthetic emeralds. It has been explained elsewhere³ that these feathers are true healing fissures (Figs. 6 and 7). There

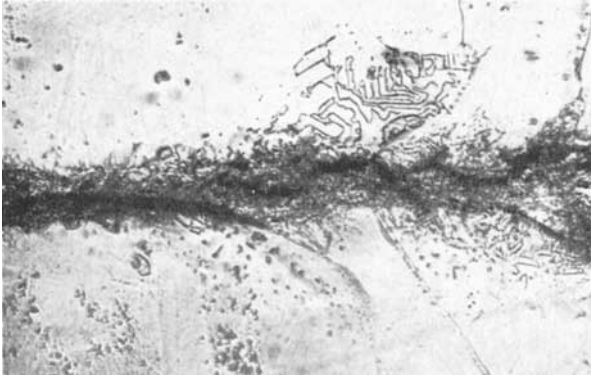


FIG. 1

The surface (111) of an ammonia-alum crystal. It bears a broader stripe of clusters, consisting of tiny, unorientated alum crystals, and caused by a great growing rate. The clusters caused tension cracks within the bearing alum crystal. One of these cracks shows the typical features of a healing fissure. 120 ×

FIG. 2

Octahedron plane of an alum crystal. A system of healing fissures starts from a cluster of tiny, rapidly deposited alum crystals. 120 ×

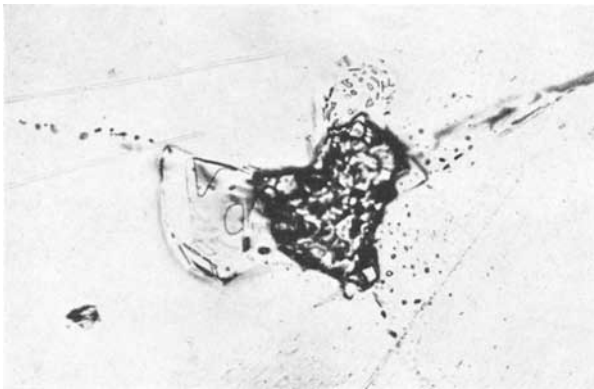
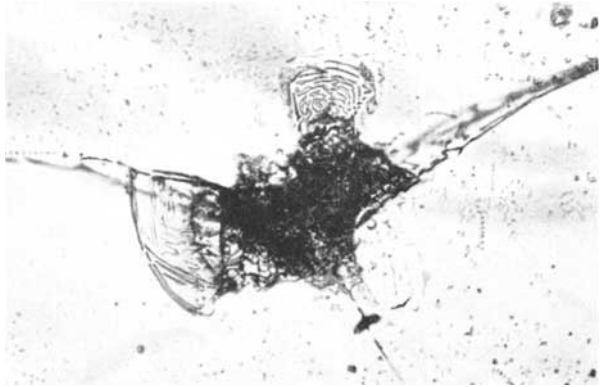


FIG. 3

Same as Fig. 2 after 6 hours in the mother liquor. 120 ×

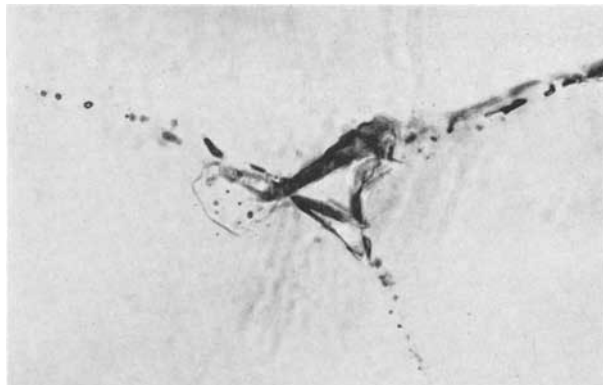


FIG. 4
*Same as Fig. 2 after 4 days
in the mother liquor. 120 ×*

FIG. 5
*Same as Fig. 2 after 12
days in the mother liquor.
120 ×*

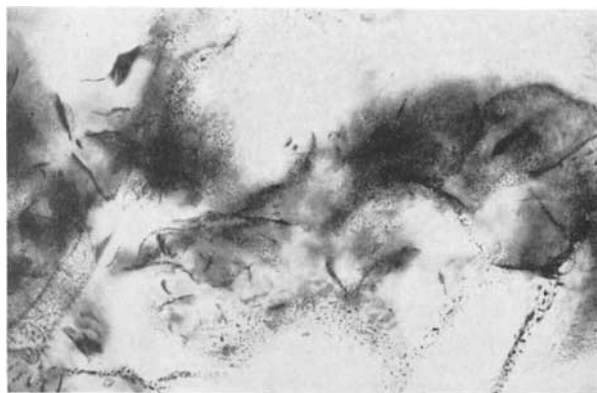
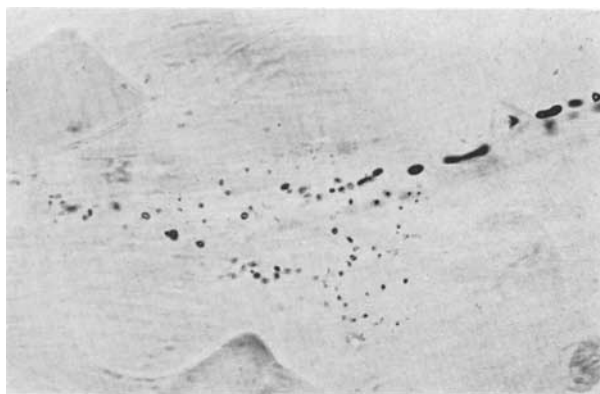


FIG. 6
*Synthetic emerald (Chat-
ham). Typical veil-like
"feathers" which are true
healing fissures. 40 ×*

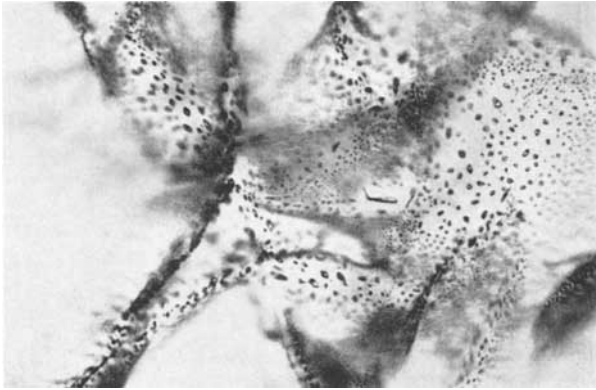


FIG. 7
 Synthetic emerald (Igemerald). Healing fissures.
 120 ×

FIG. 8
 Blue topaz, showing a set of syngenetic (early) healing fissures, intersecting each other and consisting of liquid inclusions at random orientation. 85 ×

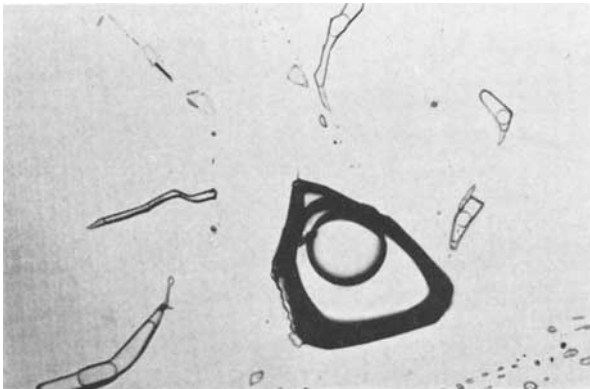
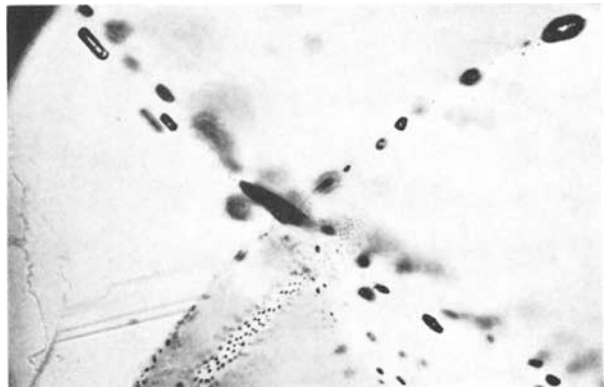


FIG. 9
 Blue topaz with a large liquid inclusion of primary origin (with broad dark rim), surrounded by syngenetic (early) smaller liquid inclusions, indicating a healing fissure. The system of inclusions is strictly parallel to the basal cleavage plane of the host crystal. 105 ×

may also exist other reasons for the formation of the cracks, like shear-tension, caused by a great gradient of temperature during the synthesis, but it seems to be certain that the relatively rapid growth of the synthetic emerald crystals was one of the main factors which caused these partly healed cracks. It must be kept in mind, moreover, that the synthetic emerald has a similar brittleness to the natural one, so that cracks can easily be formed for various reasons.

It has already been mentioned that the origin of healing fissures is a very complex matter. In the following, details are given for a number of gemstones showing healing fissures, and an explanation of the origin of the more or less healed cracks has been attempted in each case.

Topaz. This gemstone exhibits two kinds of healing fissures, one of them, shown in Fig. 8, is characterized by liquid inclusions which follow curved planes and at random orientation. The fissures may intersect each other. It can be assumed that this type of healing fissure is caused by a rapid growth of the host crystal and that the fractures are of syngenetic (early) origin.

The other kind is shown in Fig. 9. Around a broadly rimmed liquid inclusion of primary origin, smaller liquid inclusions are arranged which follow strictly the basal cleavage plane of the host crystal. They represent a nearly healed fissure which formerly had been formed along the cleavage plane of the topaz and which is also of syngenetic origin.

Scapolite cat's-eye. The tetragonal crystals of scapolite exhibit a perfect cleavage parallel to the prism face (100) and a less perfect one parallel (110). According to Fig. 10, the residues of a healing fissure follow the direction of the perfect cleavage. They form three-phase inclusions in which the liquid phase consists of carbonic acid. The solid material is represented by doubly refractive, colourless crystals of not yet known composition. It has to be assumed that these crystals are primary and, furthermore, that they caused a cleavage crack which started to heal during the growing period of the scapolite crystal. This healing fissure is of typical syngenetic origin. The marked striation of the inclusions indicates that the healing process preferred crystallographic orientated directions. The lines, which form the striation, are repeated edges between the tetragonal prism and the bi-pyramid.

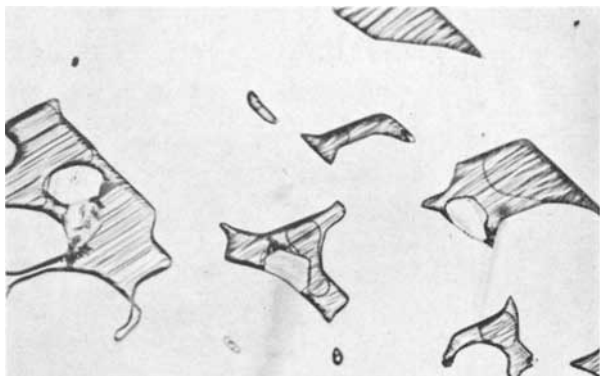


FIG. 10
Scapolite cat's-eye, showing a healing fissure in the direction of the perfect cleavage along the prism face (100). 120 ×

FIG. 11
Fluorspar with syngenetic (early) healing fissure parallel to the cleavage plane (111). 70 ×

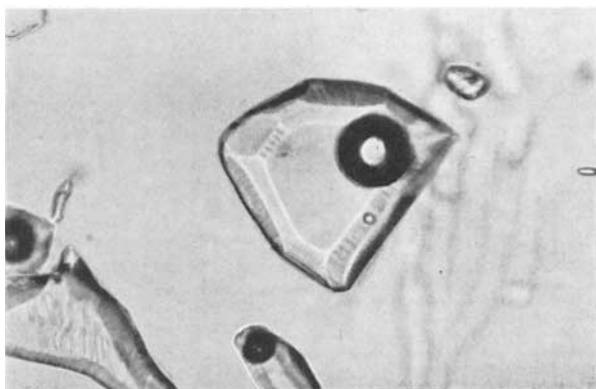
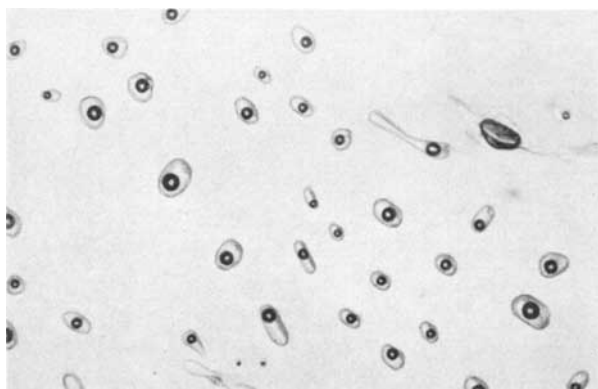


FIG. 12
Fluorspar. A single liquid inclusion of a healing fissure parallel (111), showing the crystal planes of the octahedron (111), the cube (100), and of the dodecahedron (101). 200 ×

Fluorspar. The healing fissures in the cubic fluorite often follow the octahedron plane (111), which is the direction of perfect cleavage in this crystal. Fig. 11 shows such a cleavage crack which has been healed to a certain degree. In spite of the cause of the cleavage not being known, we have to consider this particular healing fissure as of syngenetic (early) origin. The single droplets represent the residues or the "undigestible remnants" of the former filling of the cleavage fissure which could not be resorbed by the host crystal. It is worth noting that the droplets are limited by crystal planes which, as shown in Fig. 12, belong to the octahedron (111), to the cube (100), and to the dodecahedron (101).

These inclusions are not to be mistaken for the primary liquid inclusions in fluorite which firstly have been described by E. Gübelin.⁴ They are claimed to be negative tetrahedrons (or bisphenoids), filled with a liquid and showing a libella. It is easy to agree with their primary origin, but for their shape it is preferable to consider them as the threefold corner of a cube, which is more in conformity with the cubic symmetry of the host crystal.

Quartz. Most of the healing fissures in quartz, particularly in rock crystal and in amethyst, follow curved planes and at random. In some cases, interesting features can be observed, and to these belong those cracks which form the so-called "tiger pattern." Without any doubt, they are partly healed fissures. On the other hand, they are composed of two components (Fig. 13), namely of liquid inclusions and of negative crystals. Both kinds of inclusion are arranged in distinct directions, whereas the liquid inclusions at the same time have an orientation according to the basic rhombohedron. It is presumed that the negative crystals are of primary origin and that they caused "subsequently" a fissure which in its turn entrapped during the healing process the liquid inclusions. This example, therefore, is a combination of primary inclusions (negative crystals) and of syngenetic liquid inclusions, the latter owing their typical shape to certain circumstances such as a rapid healing process.

Another peculiarity is the strict orientation of liquid inclusions of a syngenetic healed crack in combination with other liquid inclusions which seem to be unorientated. Fig. 14 shows such a combination in a rock crystal with a faint brownish hue. The fissure itself is slightly curved and has no orientation within the host

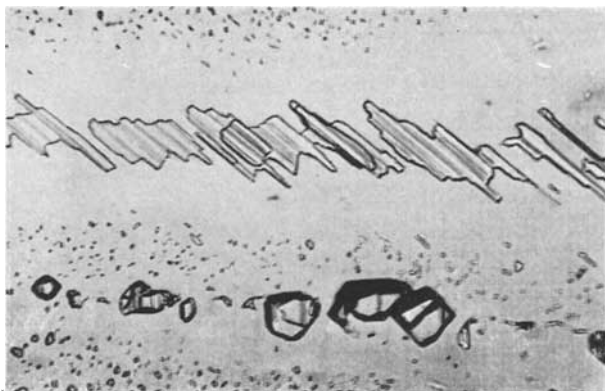


FIG. 13

Amethyst. Part of a so-called "tiger pattern." The rows of liquid inclusions alternate with other rows of negative crystals (with dark borderlines). 105 ×

FIG. 14

Rock crystal with parts of a syngenetic (early) healing fissure. 40 ×

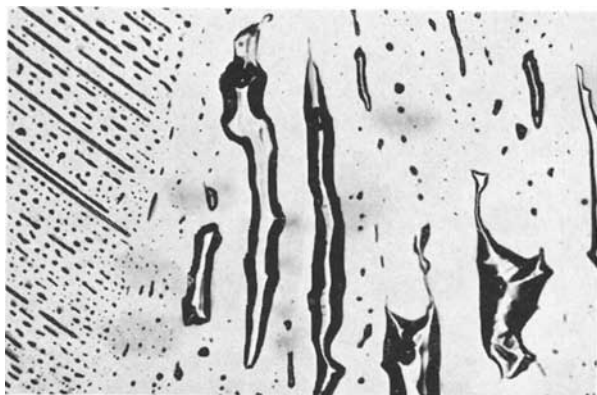
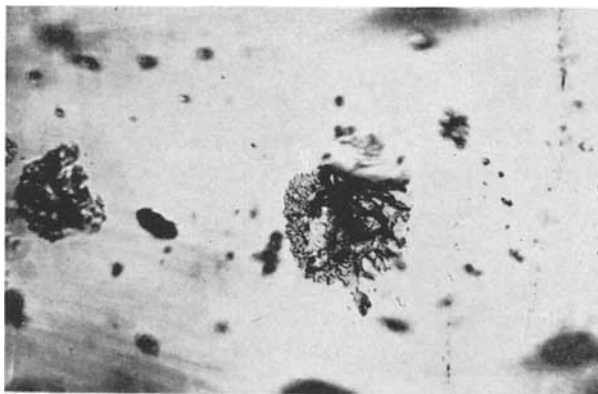


FIG. 15

Andalusite. A primary crystal inclusion (black centre) has caused a crack parallel to the cleavage plane (110) of the host crystal. The syngenetic (early) healing process left very small droplets within the area of the former crack. 105 ×



crystal. It is not possible to give an explanation for such a differentiation which, by the way, can be observed similarly in some aquamarines.

Andalusite, a rarely used gemstone, sometimes exhibits healing fissures which cover only a small and limited area. In Fig. 15, a doubly refractive crystal of primary origin caused a tension crack, which followed the direction of the cleavage parallel to the prism plane (110). The crack underwent a healing process and can now be recognized by the field of very small droplets, which surround the primary crystal inclusion nearly like a halo. This particular kind of healing fissure can be found in other gemstones. It is a typical example of early origin.

Orthoclase feldspar. A significant property of this monoclinic gemstone is the perfect cleavage along the basal plane (001) and the prism face (010) of the crystals, and both planes include an angle of 90° . In some of these stones from Madagascar, primary inclusions of dark and birefringent crystals could be observed which had caused cracks parallel to both cleavages. The early-produced cracks healed (syngenetic), and they exhibit the picture of typical healing fissures (Fig. 16).

Spinel. Even in a crystal like spinel, which does not belong to the pegmatitic series, healing fissures can be observed occasionally. Such a healed fracture is shown in Fig. 17. It is of syngenetic origin and it follows approximately the octahedron plane (111).

Tourmaline. Healing fissures in tourmaline are well known. As described by E. Gübelin⁴, they mostly consist of "thread-like capillaries of most irregular arrangement." The discoverer (Gübelin) termed them "trichites" and mentioned them to be "ultrafine tubes which are filled with a liquid." It is no doubt that these typical "trichites" are the remnants of former healing fissures of early formation.

Besides this, other inclusions in tourmaline can be observed which, so far, also seem to be of diagnostic value. In Fig. 18, liquid inclusions of characteristic triangular forms are arranged parallel to each other, following at the same time the basal plane (0001) of the host crystal. They must be considered as the "undigestible residues" of a syngenetic healing fissure, showing now the faces of the trigonal pyramid ($10\bar{1}1$). On the right of

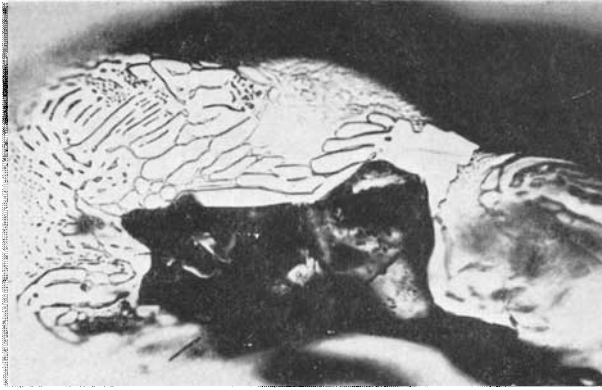


FIG. 16

Yellow orthoclase feldspar from Madagascar. A birefringent primary crystal inclusion caused two cleavage cracks which healed. One of them, seen here, exhibits the typical features of a healing fissure, particularly on its left side, where it shows a thinning like a wedge. The broad black rim near the top of the picture is the second crack, perpendicular to the first one, and out of focus. 105 ×

FIG. 17

Red spinel. A small healing fissure (centre), starting from a large crystal inclusion (below, black) and consisting of a pattern of little droplets. 105 ×

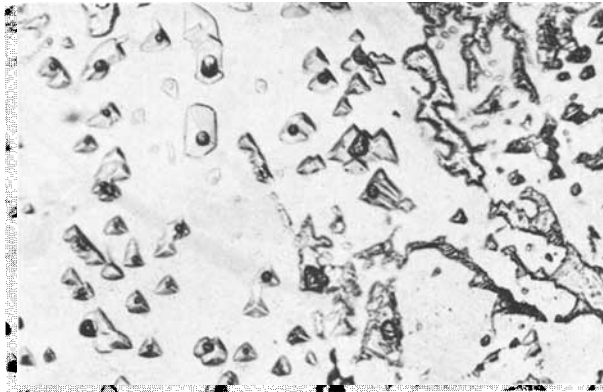
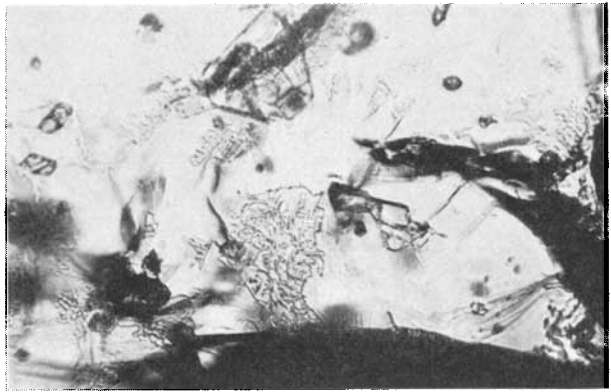


FIG. 18

Green tourmaline, California. A syngenetic (early) healing fissure parallel to the basal plane of the host crystal with liquid inclusions, forming trigonal pyramids and broader patches. 105 ×

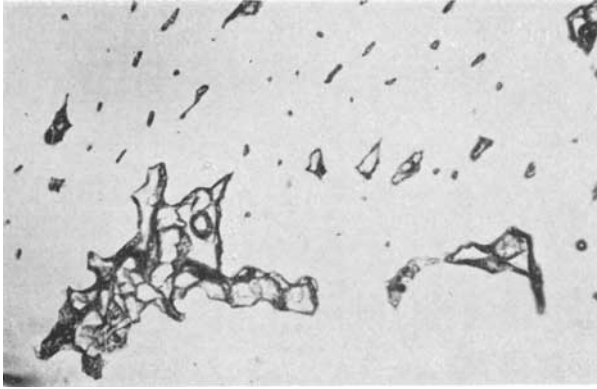


FIG. 19

Rose coloured tourmaline, California. A syngenetic healing fissure parallel to the basal plane of the host crystal, showing liquid inclusions in various phases of resorption. 105 ×

FIG. 20

Rose coloured tourmaline, California, with an epigenetic (late) healing fissure. 40 ×

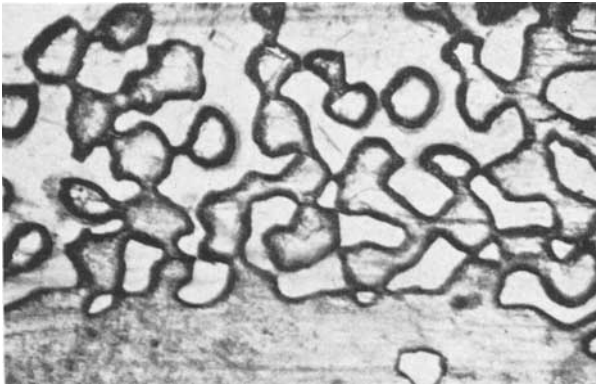
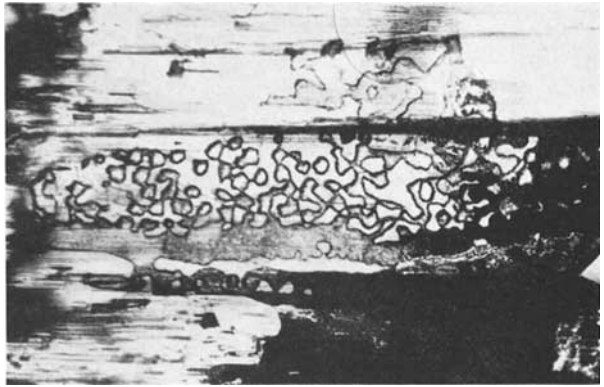


FIG. 21

Same as Fig. 20. 120 ×

Fig. 18, the liquid inclusions form broader and coarser patches which indicate that here the resorption (or the healing process) could not go so far as on the left side of the picture.

Confirmation for the correct characterizing of these inclusions is given by Fig. 19. Here, the healing fissure is nearly completely healed, particularly in the upper half of the picture. Only very thin capillaries and small droplets of liquid inclusions remain in the presence of a former healing crack, while the coarser patches in the lower part of the picture confirm the syngenetic origin.

In the same rose-coloured tourmaline, a typical epigenetic, partly healed crack of very late origin could be observed (Fig. 20). The filling of this fracture is of red-brown colour and does not contain any liquid. At higher magnification (Fig. 21), the first impression, as if grains are distributed throughout the fissure, is confirmed by the observation that a healing process has started, producing particles of greyish colour with a broad, dark rim. This particular filling must have happened long after the time when this tourmaline had left its mother-rock.

Beryl, a typical pegmatitic mineral, exhibits a great number of healing fissures, the origin of which is mostly syngenetic and not so often epigenetic. In many cases, an orientation of the healing cracks can be observed with respect to the host crystal. To these belong the best known three-phase inclusions, which are so typical of the Colombian emerald. They must be considered as parts of healing fissures which, with some deviations, follow generally the basal plane of the emerald. This is a direction in which the beryl has a weak or indistinct cleavage.

In *aquamarine*, three types of healing fissures could be observed, namely those

- (a) parallel to the main or c-axis of the host crystal,
- (b) parallel to the basal plane, and
- (c) at random orientation.

Examples for (a) are given in Figs. 22 and 23. Both pictures show typical healing fissures of early origin. They consist of liquid inclusions, which during the resorption or during the healing process developed elongated forms parallel to the direction of the c-axis of the host crystal. It is interesting to mention that these pictures furnish more than one hint for the healing process itself. Without

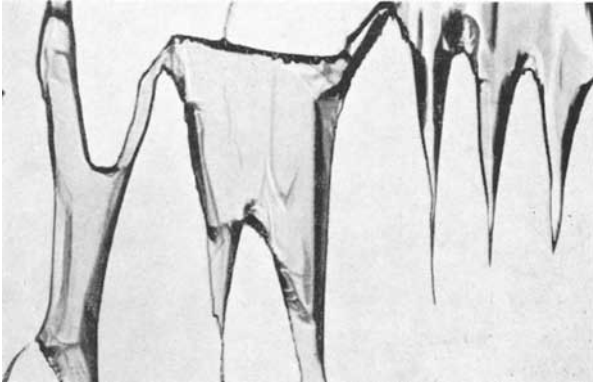


FIG. 22
Aquamarine. Strongly re-sorbed liquid inclusions of a healing fissure parallel to the c-axis. 105 ×

FIG. 23
*Aquamarine. Part of the same healing fissure as Fig. 22. 105 ×
 (In Fig. 22 the direction of the c-axis is from top to bottom; in Fig. 23 it is from left to right.)*

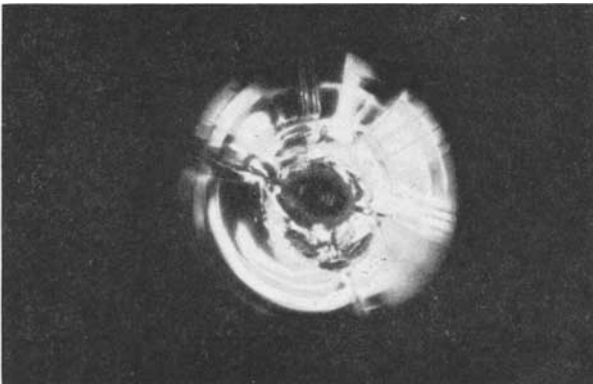
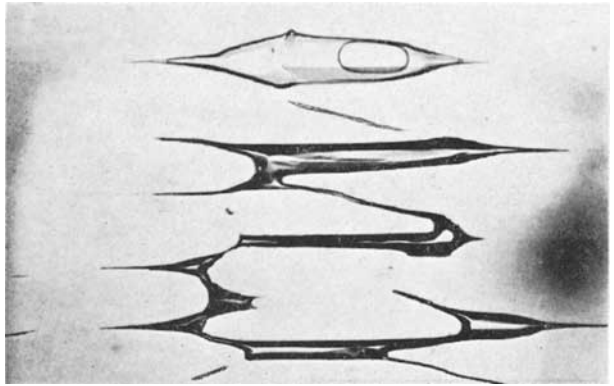


FIG. 24
Aquamarine. A circular crack along the cleavage plane (0001), caused by a crystal inclusion (centre); reflected light. 100 ×

any doubt, the first thing that happened was the origination of a crack, most probably caused by rapid growing of the aquamarine. The second step must have been the filling of the fissure with material, that surrounded the host crystal and which we are accustomed to call "mother-liquor." The following step will have been the deposition of aquamarine substance on the inner walls of the crack, and this happened in a preferred direction, namely in the main growing direction of beryl, the c-axis.

It is not difficult to imagine that this particular step, the real healing process, is also responsible for the fact that some of the mother-liquor has been entrapped within the healing fissure. In the following period, conditions must have been in existence which enabled the aquamarine crystal to resorb such parts of the entrapped mother liquor, as could further build up the crystal edifice, or as could occupy intermediate places within the crystal lattice. The latter process would be a true resorption. In any event, there remained a residue of non-suitable material which, with regard to the healing fissures, mostly consists of a liquid.

(b) Wonderful examples of healing fissures parallel to the basal plane of the aquamarine crystal are the so-called "snow flake" inclusions. Details about these inclusions of such peculiar beauty have recently been published elsewhere.⁵ It could be found that the cause of each of these "snow flakes" is a primary embedded crystal inclusion which produced already during the growing period of the aquamarine a little crack in its host crystal. Mostly the crack has a circular shape, and it is always parallel to the basal plane as the direction of a weak cleavage in aquamarine. This crack started to heal immediately after its origin. Now, this healing fissure consists of six-sided droplets which are arranged round the primary crystal inclusion according to the symmetry of the host crystal. Again, the liquid inclusions are the "indigestible remainders" of the former filling of the crack, and they represent a very early (syngenetic) originated healing fissure.

A convincing example for the correct explanation given for the origin of the "snow flakes" was found in another aquamarine, probably from Brazil. Here, a crystal inclusion, possibly ilmenite, had caused by one reason or the other a circular crack along the cleavage direction (basal plane) of the host crystal. In reflected light (Fig. 24), the crystal in the centre is hardly to be seen; but

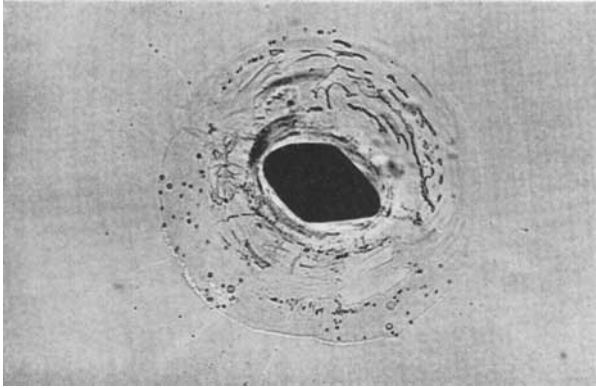


FIG. 25

Aquamarine. The same crack as in Fig. 24 in transmitted light, revealing the cleavage crack as a typical healing fissure. 120 ×

FIG. 26

Aquamarine. The same healing fissure as in Fig. 24 and 25 in transmitted light with crossed polarizers. The dark cross and the four bright fields respectively indicate in this direction (\parallel c-axis) of single refraction the presence of a distinct tension in the host crystal, caused by the solid crystal in the centre. 120 ×

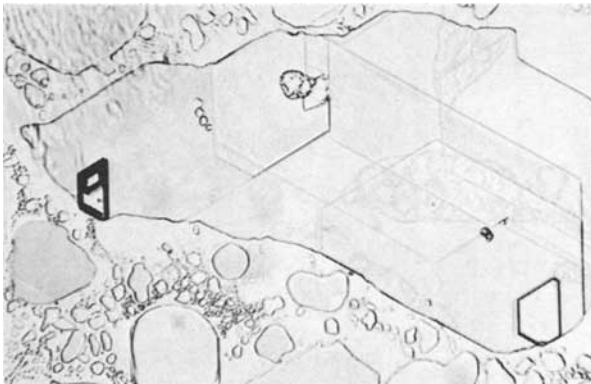
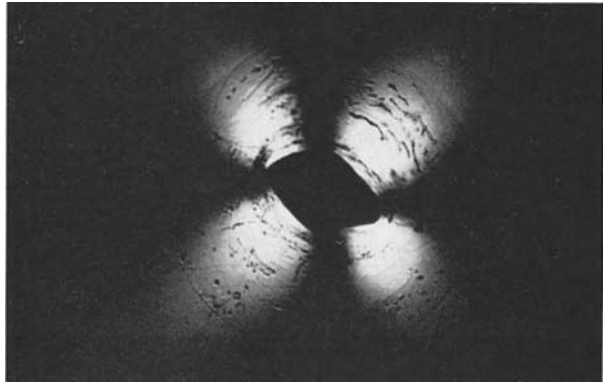


FIG. 27

Aquamarine. Films of syngenetic (early) liquid inclusions parallel to the basal plane of the host crystal. 100 ×

the cleavage crack itself acts in some way like a mirror. In transmitted light (Fig. 25), at a somewhat greater enlargement than Fig. 24, the crack reveals itself as a typical healing fissure with liquid inclusions, forming a kind of halo around the primary crystal in its centre. In polarized light, the expected darkness in this direction is not uniformly present, but only in the area of a cross, the branches of which indicate the directions of vibration of the combined set of polarizers (Fig. 26). The four bright fields mark a strongly developed tension, which covers the area of this particular healing fissure, and which is caused by the central crystal. It is amazing that the tension still exists in spite of the already started healing process. Regarding the time of its origin, it is certain that this healing fissure was formed during the growing period of the aquamarine (syngenetic), but also that by some unknown reason, the healing process itself went on at a relatively slow rate. Therefore, this inclusion could be termed an "under-developed snow flake."

Another kind of syngenetic inclusion parallel to the basal plane of the aquamarine is represented by very thin films of liquid inclusions (Fig. 27). They occur in different sizes showing rounded forms, or they are limited by straight lines, indicating the first order prism. The relatively large inclusion in Fig. 27 seems to be separated by some thin lines in several parts. In reality, these are only border lines of areas of different thickness of the same film inclusion. The films are so thin, that in transmitted light they have only a faint contrast against the surrounding host crystal, and therefore can easily be overlooked. In reflected light, however, they show the rainbow- (true interference-) colours, which vary throughout the entire visible spectrum according to the thickness of the liquid inclusions or parts of it.

Finely healing fissures of epigenetic (late) origin parallel to the basal plane of the aquamarine could be observed (Fig. 28). Here, a cleavage crack is partly filled with dark brownish crystal needles in a dendritic-like arrangement. From this it is assumed that the origin of the crack and its filling lies in a relatively late period, i.e. after the growing of the host crystal.

The needles are arranged in groups and in straight or bended directions. They strictly follow the directions of the hexagonal symmetry of the aquamarine. Although they resemble ilmenite crystals in colour, which often can be found in aquamarine, it seems to be unlikely that they are identical with this mineral.



FIG. 28
Aquamarine. An epigenetic healing fissure parallel to the basal plane of the host crystal, showing dendritic-like arranged crystal needles of unknown nature. 100 ×

FIG. 29
Aquamarine. A syngenetic healing fissure with coarser liquid inclusions, overlying a smaller healed crack. 40 ×

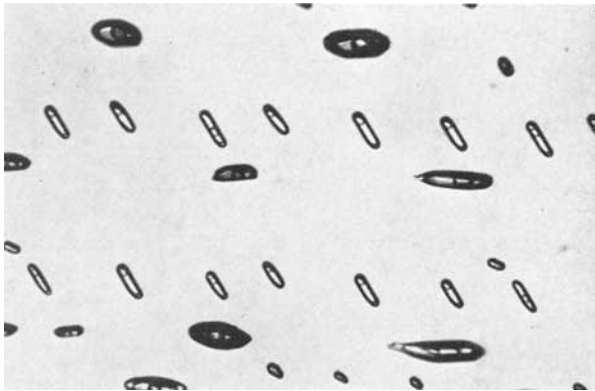
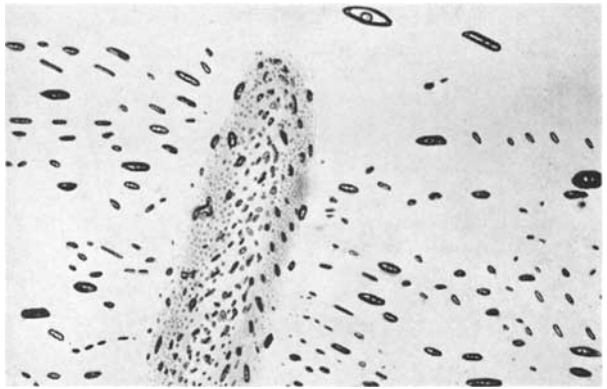


FIG. 30
Aquamarine. Part of the healing fissure of Fig. 29. 110 ×

(c) Healing fissures at random orientation are most common in aquamarine. It seems to be certain that in most cases they have been formed by a relatively rapid growth of the host crystal, and therefore they are mostly of very early origin.

In Fig. 29, parts of such a broadly extended healing fissure can be seen, consisting of coarse liquid inclusions and overlying a smaller healed crack with the typical wedge-shaped borders. On the right of the picture, some of the inclusions seem to follow preferred directions. Under higher magnification the arrangement of the liquid inclusions reveals an orientation which corresponds with the symmetry of the host crystal (Fig. 30). In some way, it is a temptation to consider these inclusions as of primary origin. But this would not be correct, as the healing fissure itself is unorientated and shows typical curvatures. It can only be concluded that the healing process started early and lasted long enough to bring the unused material, the liquid inclusions, in directions which are suitable for the symmetry of the aquamarine.

Another kind of unorientated healing fissure in aquamarine is shown in Fig. 31. Here, the elongated hose-like liquid inclusions form a pattern which seems to be identical with the features of a conchoidal fracture. In another picture of the same aquamarine (Fig. 32), the resemblance with a conchoidal fracture is even more distinct. Most probably, the liquid inclusions of Fig. 31 and 32 represent a healing fissure which was formed after the growth of the aquamarine had ended, while the crystal was still in contact with the mother liquor. Perhaps we have in this case a transition from the syngenetic to the epigenetic origin of healing fissures.

A good example of an epigenetic healing fissure of random orientation in aquamarine is given in Fig. 33. It represents the filling of a flat crack with conchoidal markings. The filling consists of ramified liquid inclusions and a solid material of brown colour in different shades. The bright areas indicate the places of an advanced healing.

Zircon. Healing fissures in zircon from Mogok or Ceylon exhibit a pattern of elongated liquid inclusions which show by their rectangular arrangement an adaption to the tetragonal symmetry of the host crystal. In most of the cases they are nearly parallel to the first order prism (110) and follow the direction of the main or c-axis. They are of syngenetic origin.

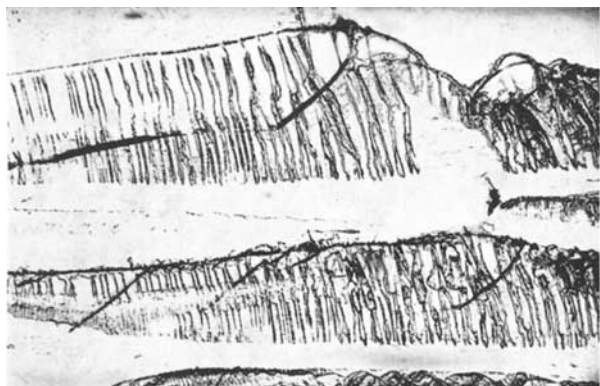


FIG. 31
Aquamarine. Unorientated healing fissures with the features of conchoidal fracture. 105 ×

FIG. 32
Aquamarine. Feather-like border of an unorientated healing fissure consisting of liquid inclusions. 105 ×

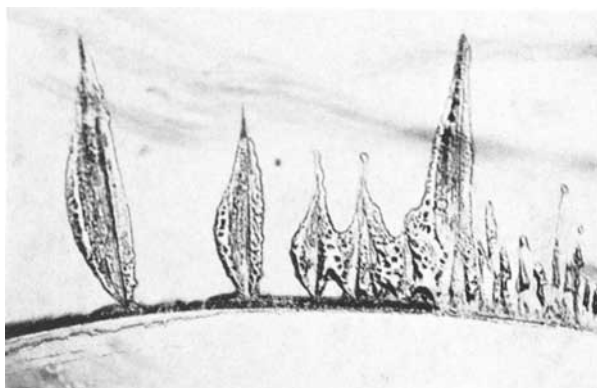


FIG. 33
Aquamarine. An unorientated healing fissure of epigenetic origin. 35 ×



FIG. 34
Brown zircon from Madagascar. An epigenetic healing fissure, containing tiny droplets and some crystals (left). 120 ×

FIG. 35
Same as Fig. 34, but crossed Nicols. 120 ×

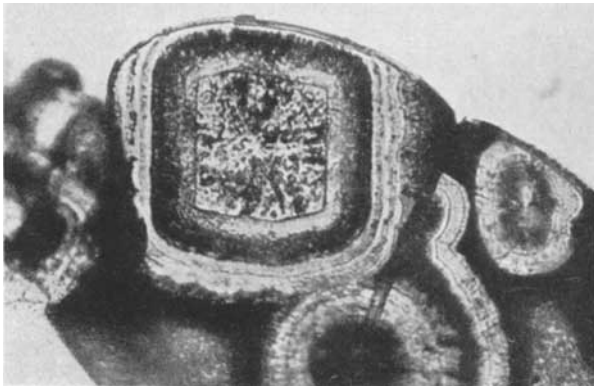
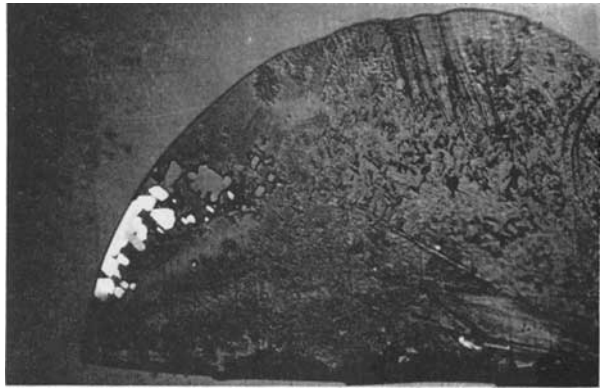


FIG. 36
Brown zircon from Madagascar. An epigenetic healing fissure, consisting of solid material. 420 ×

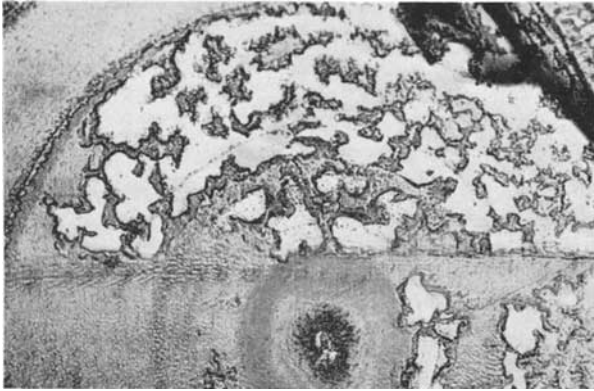


FIG. 37

Brownish zircon from Madagascar with epigenetic healing fissures, containing disc-like aggregationen of iron oxide. Here parts of such a deep red coloured disk have been resorbed by the host crystal, forming a peculiar pattern. 120 ×

FIG. 38

Brownish zircon, same healing fissure as Fig. 37. Between the red disks are colourless crystal needles, mostly radiating from one centre. 120 ×

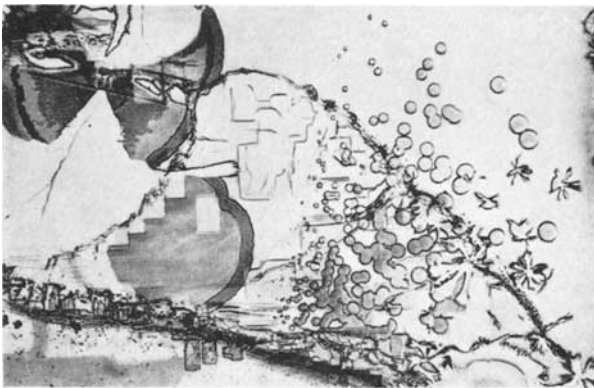
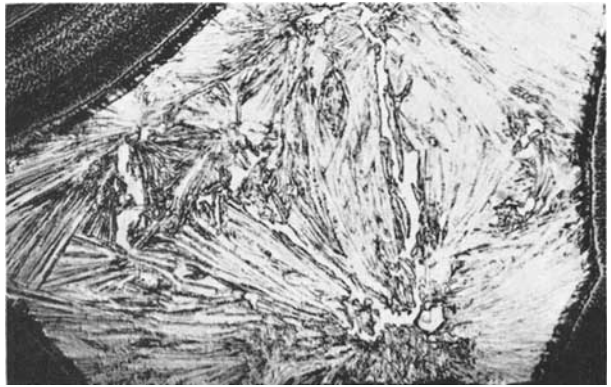


FIG. 39

Brownish zircon from Madagascar. A healed cleavage crack (epigenetic), with strangely formed deposits of iron oxide. 105 ×

Recently, some brownish-coloured zircons from Madagascar arrived in Europe. The stones contain healing fissures of extraordinary shapes, which so far have not been described elsewhere.

One of the Madagascar stones contained a healing fissure which is shown in Fig. 34. It consists of tiny droplets, forming a shagreen texture, and some crystals near the left edge. The crystals are doubly refractive (Fig. 35), but otherwise nothing is yet known about their nature. The shapes of the fissure and of the tiny droplets indicate that most probably its origin is epigenetic. This seems to be confirmed by another part of the same crack, which exhibits an unusual pattern (Fig. 36). It consists of solid material, the nature of which could not yet be determined in spite of the application of high enlargement. There is no doubt that this particular filled or healed crack is of epigenetic origin.

Another brownish-coloured zircon from Madagascar showed healing fissures parallel to the main cleavage plane, the first order prism (110) of the host crystal. The filling of the cleavage crack proved its epigenetic (late) origin. It consisted of iron oxide forming greater and smaller discs of deep red colour. Some of these beautiful looking formations have been submitted to a resorption process which produced peculiar patterns (Fig. 37). The spaces between the discs are occupied by crystal needles, mostly starting from one centre (Fig. 38). These singly refractive needles are typical of a rapid crystallization, and this indicates, together with the aggregation of iron oxide, a very late origin of the healing fissure.

Other zircons from the same source contain similar epigenetic healed cleavage cracks which are puzzling by their strange appearance. Fig. 39 and 40 give only a small selection of the manifold formations of the deposition of heterogeneous material and its partial resorption within an ordinary cleavage crack.

Garnet. Healing fissures in garnets are encountered only occasionally. In almandine garnet very early fissures could be observed (Fig. 41) which without any doubt have been submitted to a long-lasting healing process. This conclusion seems to be correct because the healed crack mostly consists of doubly refractive crystal inclusions which, moreover, are arranged in certain crystallographic directions.



FIG. 40
 Same healing fissure as
 Fig. 39, showing rectangular
 fields of resorption.
 105 ×

FIG. 41
 Almandine garnet. A very
 early healing fissure, mostly
 consisting of double refractive
 crystal inclusions.
 110 ×

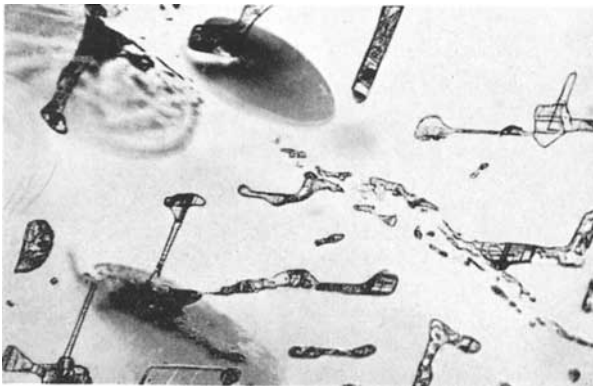
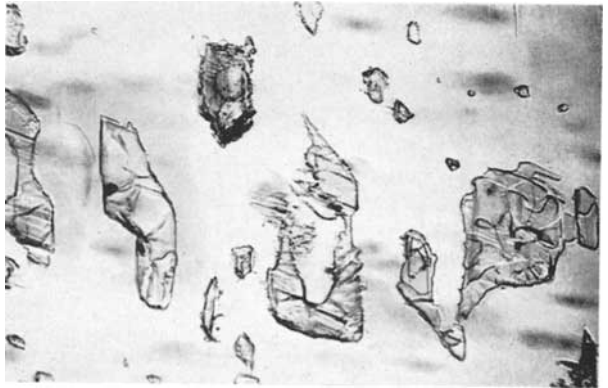


FIG. 42
 Almandine garnet. An
 early healing fissure, the
 former liquid inclusions of
 which have been partly
 crystallized. 105 ×

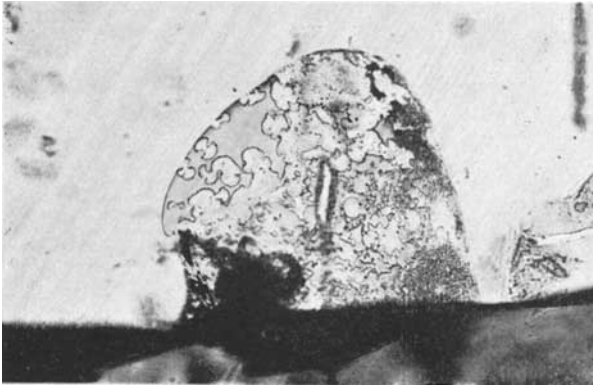


FIG. 43
Almandine garnet from East Africa with a typical healing fissure of late origin. 105 ×

FIG. 44
Almandine garnet from Madagascar. An inclusion of a slightly rounded zircon crystal. 110 ×

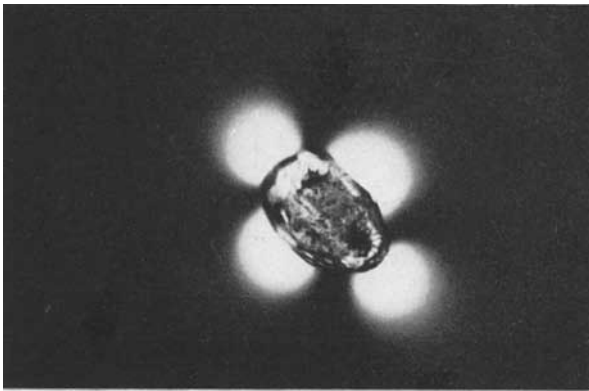


FIG. 45
Same as Fig. 44, polarized light. The four bright fields around the zircon indicate the area of a strong tension within the garnet. 110 ×

Another almandine (Fig. 42) showed a syngenetic healing fissure, the former liquid inclusions of which have been crystallized. They likewise follow preferred directions, which most probably are the edges of the dodecahedron. The newly formed crystals are birefringent. In some cases they have caused disc-like tension cracks, parallel to each other and to a crystal plane likewise, the indices of which could not be determined. Some of the discs show the characteristic brownish colour in transmitted light, which indicates that they are true cracks. Others exhibit the typical pattern of a beginning healing process. Examples of both kinds are to be seen in the upper left corner of Fig. 42. They are of epigenetic origin. The inclusions of this almandine show the rare phenomenon of both kinds of early and late healing fissures present in the one stone.

In an almandine from East Africa, a typical healing fissure of late origin could be observed (Fig. 43). It consists of very small liquid films with characteristic rounded forms.

Another example may be given of the strong tension which an included zircon causes on its host crystal. As is well known, inclusions of zircon in gemstones, as in garnet likewise, can cause cracks, which sometimes look like a halo around the included zircon. It is believed that these cracks are formed by the shear tension, which the zircon exerts on its host crystal. In an almandine from Madagascar, a slightly rounded zircon was found which had not yet caused such tension cracks in its host (Fig. 44). In polarized light, four bright fields around the zircon disclosed an area of strong tension within the garnet (Fig. 45). If this tension is by any reasons increased only a little, the well-known cracks are originated which afterwards may be submitted to a healing process. In this phase, Fig. 45 shows a not yet developed crack or an "unborn" healing fissure.

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