# THE ORIGIN OF NEGATIVE CRYSTALS IN GEM STONES

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AN interesting explanation of the origin of negative crystals as inclusions in gem stones is given by E. Roedder in his article "Ancient Fluids in Crystals"(1). Principally, the author regards the negative crystals as the final phase of a healing process of a fracture, during which the fracture was still in contact with the mother-liquor. He demonstrates the steps of the healing and the formation of negative crystals in a block diagram, which is reproduced in Fig. 1.

His observation could be confirmed by heating a synthetic ruby having a fracture at temperatures below the melting point of corundum for a considerable time. Before heating, the synthetic ruby was boiled in water to expel the air from the fracture and to replace the air as far as possible by water. As shown in Fig. 2, a certain amount of air still remained in the fissure indicating that the walls of the fracture are not perfectly even.

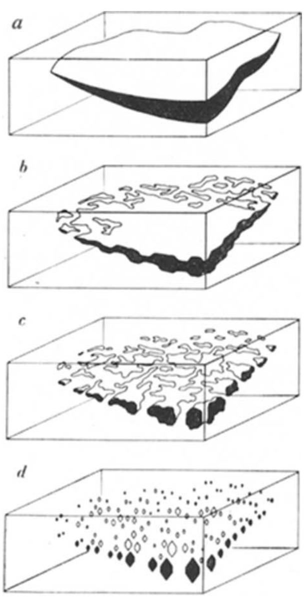


FIG. 1. *Secondary negative crystals formed in the fracture of a crystal:*
(a) *Crystal with fracture embedded in a liquid;*
(b) *Solution and redisposition of material from the liquid on the fracture surfaces results in dendritic growth;*
(c) *which meet and close off small volumes of liquid;*
(d) *these gradually lose surface area and become rounded masses or hollow negative crystals (after R. Roedder).*

FIG. 2. *A synthetic ruby with a fracture, which is partially filled with water. The dark parts of the fissure, including the "channels", are films or hoses of air, while the bright or transparent rest of the fracture is filled with water.* 65 ×

The result of the first period of heating (7 days at 1950°C) was surprising as the structure and the arrangement of the "inclusions" are heavily altered (Fig. 3). Besides the strongly developed channels of air, there are still thin films of water with a very weak relief.

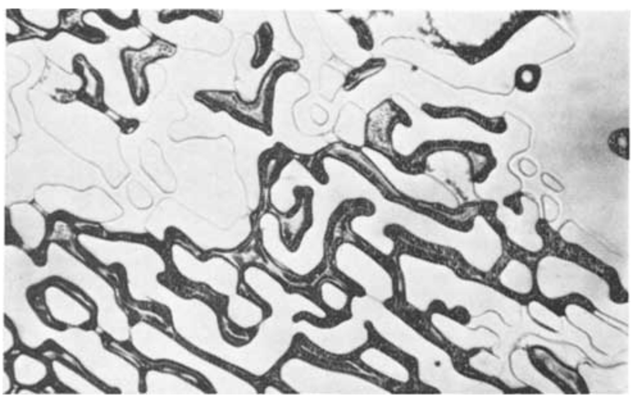

FIG. 3. *Same crack after heating the synthetic ruby during 7 days at 1950°C. The dark network of channels is filled with air, while the bright and transparent and irregularly-formed patches are films of water.* 65 ×

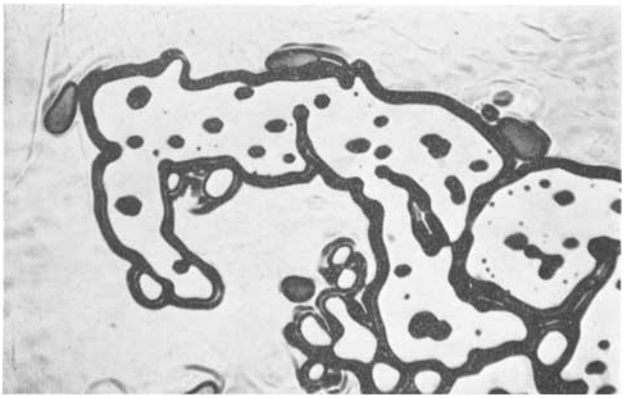

FIG. 4. *Same crack after heating the synthetic ruby during two months at 1800°C. 65 ×*

It is hard to understand that a certain amount of water did resist the heat-treatment at such an extremely high temperature. In some way, the dendritic network in Fig. 3 can be compared with the intercommunicating hoses in certain natural sapphires.

In continuing the heat-treatment for a very long time (two months at 1800°C), the pattern of the inclusions altered drastically. The hoses diminished in number and a concentration of the channels took place in such a way that they parted into smaller sections. This change was caused by a progressive healing process of the

FIG. 5. *Part of Fig. 4. Newly formed and parallel orientated negative crystals. 120 ×*

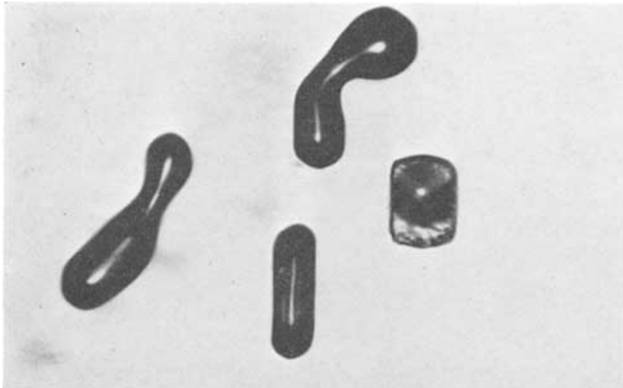

FIG. 6. *Same crack of the synthetic ruby after prolonged heating, with incipient negative crystals and with a kind of two-phase inclusion (right).* 450 ×

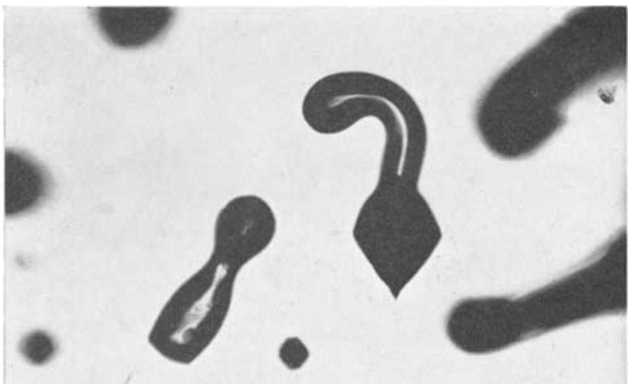

FIG. 7. *Another negative crystal starting from a curved air-filled hose. Same crack as in Fig. 4.* 450 ×

fracture. At the same time, the hollow and air-filled sections of the former hoses started to crystallize, i.e. their walls became crystal faces and their longest extension follows now a preferred crystallographic direction of the host crystal, the c-axis. In Fig. 4, a general view is given while in Fig. 5 the newly formed negative crystals are shown at a greater magnification. At a still greater enlargement, the crystallizing of the "air bubbles" can be observed and also the tendency to be regulated into a distinct direction according to the lattice of the surrounding synthetic ruby (Fig. 6 and 7).

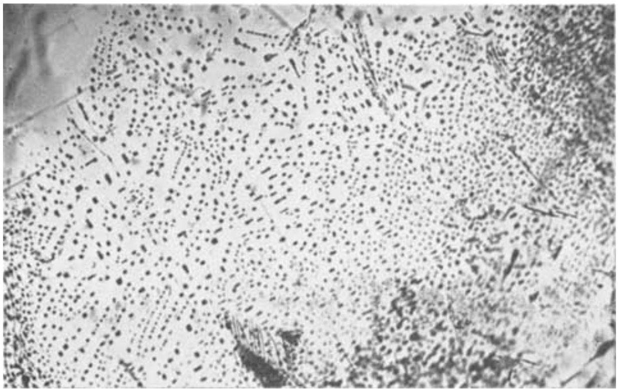

FIG. 8. *Blue spinel from Ceylon. General view of a healed crack which now is marked by a multitude of rectangular black inclusions.* $40\times$

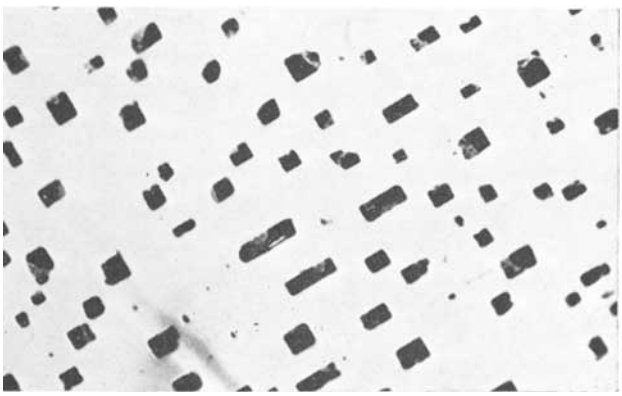

FIG. 9. *Same as Fig. 8 at a magnification of* $240\times$

With natural stones, a good example for this kind of negative crystals is given by the spinels. As is shown in Fig. 8, a former crack, which now is healed, contains a very great number of dark and rectangular inclusions which sometimes have been mistaken for tiny octahedrons of magnetite—another member of the spinel family. At higher magnification (Fig. 9), the dark inclusions are seen to be negative crystals which are filled partly with a black and opaque material, partly with transparent and doubly refractive crystals. They seem to be the deposits of material which is unsuitable for the healing process of a crack within the spinel.

In summarizing, the described negative crystals are originated by the healing of a crack. On that account, they are of secondary origin with respect to the host crystal.

On the other side, there are known other negative crystals which are originated as the result of a defect of a growing plane or as a disturbance in the growth of the host crystal. They are also characterized by crystal faces which in many cases are not so well developed as those of the secondarily formed counterparts. Obviously, they are grown simultaneously with the corresponding plane of the host crystal in small steps which is indicated now by a fine striation as shown in Fig. 10, or by irregular forms as it is demonstrated by

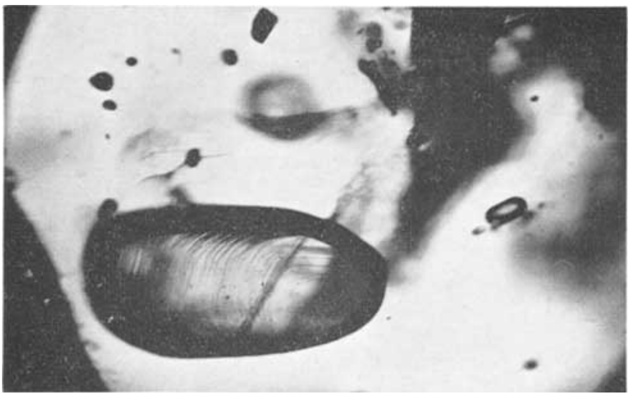

FIG. 10. *Ruby from Burma with negative crystal. 110 ×*

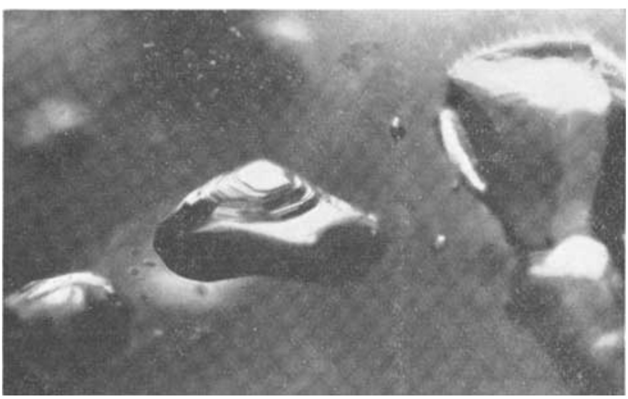

FIG. 11. *Ruby from Burma with negative crystals. 190 ×*

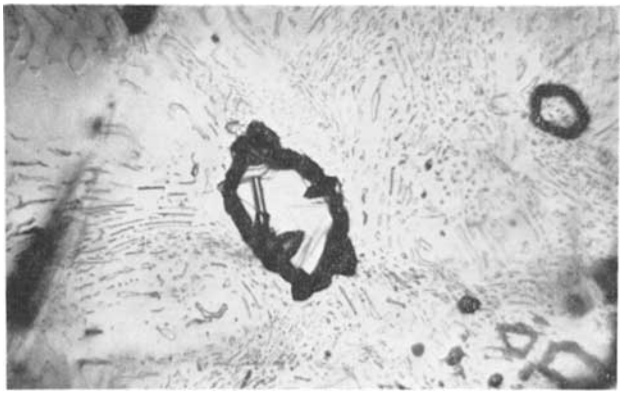

FIG. 12. *Brownish beryl from Madagascar with negative crystal.* 70 ×

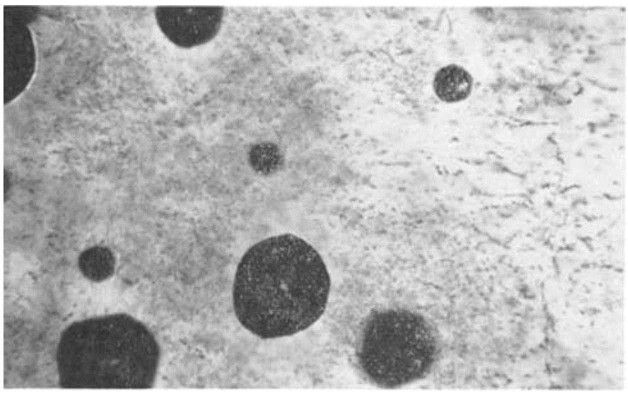

FIG. 13. *Peridot from Hawaii with rounded gas bubbles = negative crystals.* 65 ×

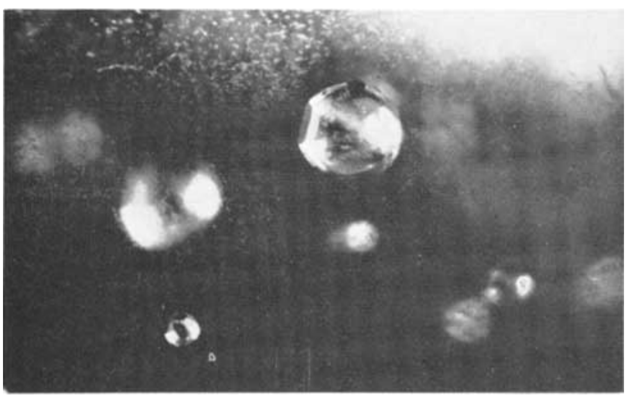

FIG. 14. *Same peridot in reflected light.* 65 ×

Fig. 11 and Fig. 12. This kind of negative crystals has to be regarded as primary inclusions which, as a rule, occur single and in greater sizes.


SUMMARY:

*Secondary* negative crystals as inclusions in gem stones are small or tiny and they occur crowded or in great numbers. In most cases, they follow a more or less curved plane which represents a former crack.

*Primary* negative crystals occur singly and have different sizes. Most of them exhibit greater dimensions than the secondarily formed crystals. Additionally, a peculiarity must be mentioned, the peridot from Hawaii. This particular gem stone is known to contain rounded gas bubbles as shown in Fig. 13. In reflected light, however, the bubbles exhibit crystal faces which indicate that the puzzling inclusions are negative crystals (Fig. 14). The origin of the bubbles is considered to be primary, i.e. they are originated during the growth of the peridot crystal. It is interesting to speculate whether a subsequent rise of temperature during growth caused a partial evaporation of the peridot material and if by such a process the bubbles, or the negative crystals respectively, have been formed in different sizes. On the other side, the origin of the negative crystals in peridot can be regarded as analogous to the genesis of gas bubbles in synthetic spinel, which sometimes display crystal faces and are negative crystals likewise. For these, E. Gübelin gives two instructive photomicrographs in his book on inclusions(2).

Finally, it must be mentioned that in the material which was available for the investigation, no glassy drops of similar appearance could be observed.



The author is indebted to Mr. B. W. Anderson, London, for his generous gift of two chromium peridot pebbles from Hawaii beaches.


REFERENCES


1. Roedder, E. *Ancient Fluids in Crystals.* Scientific American, Oct. 1962, 2-11.
2. Gübelin, E. J. *Inclusions as a Means of Gemstone Identification.* Gemological Institute of America 1953. Fig. 21 and Fig. 22 p. 57.