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# MICROSTRUCTURES ON PANNA DIAMOND SURFACES

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## ABSTRACT

Optical studies have been made of the microstructures on the natural faces of diamond obtained from Panna mines, India. The trigons, the block pattern and the ring cracks have been observed to exist simultaneously on the natural faces of a large number of crystals. From the observations made it is conjectured that the Panna diamonds might have been subjected to solution in nature, and therefore the trigons along with the block pattern and the ring cracks might have been formed in this manner. On the natural face of one crystal rows of broken trigons have been found, and an exactly similar pattern has been produced in the laboratory by etching the octahedral face of calcium fluoride in nitric acid solution.

## INTRODUCTION

The study of the microstructures on the faces of natural crystals throws important light on the history of growth of the crystal and hence it has been of great interest. A study of the surface topography of natural diamond faces has revealed a variety of surface markings. Early observations on the microstructure of natural diamond faces have been recorded by Fersmann and Goldschmidt (1911), Williams (1932) and many others. More detailed studies of the microstructures on the various faces of natural diamond have been made by Tolansky and his school; chief amongst these are Tolansky and Wilcock (1946), Halperin (1954), Tolansky and Emara (1955), Tolansky and Pandya (1954), and a detailed account of this has been given by Tolansky (1955). The characteristic feature shown by a large number of diamond octahedral faces is the appearance of equilateral triangular depressions oriented so that their corners point towards the edges of the octahedral faces. Similarly the cubic faces are characterised by square-shaped depressions. It is reported by Tolansky and Pandeya (1961) that the rounded dodecahedral faces have elevated microdisc patterns which, according to them, are formed by a solution process. Tolansky and Emara (1955) have reported that the dodecahedral faces of diamond are more susceptible to etching than the octahedral faces. It seems that the observations made by the above mentioned investigators were largely on South African diamonds.

The controversy still exists regarding the origin of trigons on the octahedral faces, *i.e.*, whether they have been formed due to growth or due to solution. The study of microstructures is of interest as it reveals the conditions under which the crystal has grown. With a view toward getting some additional information regarding the growth history an attempt is made in this paper to study the microstructures on the natural faces of diamonds obtained from Panna mines, India. No literature on the microstructures on the faces of these crystals exists. Indeed it will be seen that these studies have shed some more light on the growth history of diamond, in general.

For these investigations Panna crystals of different habits were purchased by us from Pankaj Diamond Die Works, Surat, India. Most of the crystals had rounded faces, and it was difficult to find even a few crystals of octahedral habit having flat faces. A number of crystals of various habits were examined and from observations made on a large number of crystals of each habit, only the observations made on few of them which are typical of its class are described. This study has revealed that the faces examined show a variety of surface markings, out of these only those which we thought would be helpful in elucidating the history of growth and growth mechanism are described here.

## Observations

*Observations on Crystal No. 4.* This crystal is an octahedron slightly yellowish in color. The microstructures on its various faces are shown in Figs. 1, 2, and 3. In Fig. 1 the usual trigons are clearly seen. We have verified that the orientation of these trigons is as usual. The surface appears to be very rugged, and the trigons are seen interfering with each other. Figure 2 represents some other region in which the trigons in broken condition are clearly seen. It is interesting to see some irregular shaped isolated features in Figs. 3 and 4.

To decide whether these features are elevations or depressions they were examined by a light profile microscope (Tolansky, 1952). Thus Fig. 5 represents the multiple light profile across such features; this reveals that they are elevations, and the height of one at the center is 1.0 micron. It is thus clear that these features are similar to the elevated microdisc patterns observed by Pandeya and Tolansky (1961) on the dodecahedral faces of diamond, but that they are in a broken condition. These features have an important bearing on the conclusions drawn later.

Figure 6 represents another face of the same crystal in which some trigons having sharp corners and rectilinear sides as usual are clearly seen. Along with the trigons the block pattern reported by Omar *et al.* (1954) is also clearly seen in the middle of the photomicrograph. A similar block pattern observed on another face of the same crystal is represented in Fig. 7. In this figure, also along with the block pattern, the trigons are clearly observable. Indeed, it very interesting to find the block pattern on the natural (111) face of diamond, resembling completely the block pattern produced by etching diamonds in laboratory as reported by Omar *et al.* (1954) along with the trigons.

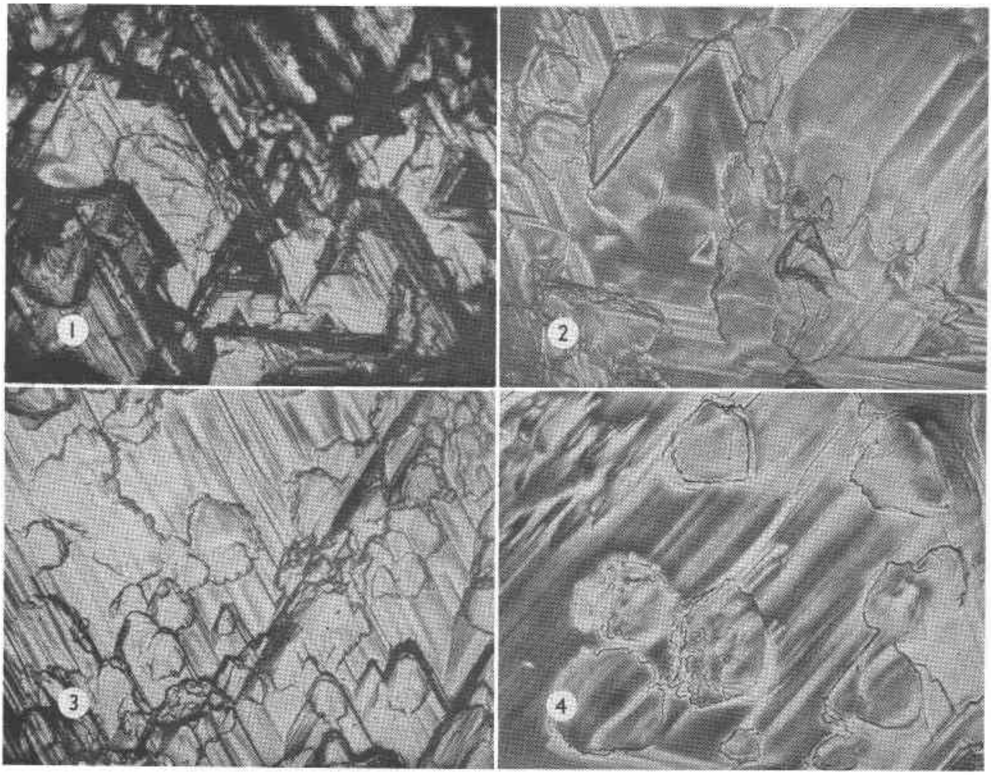
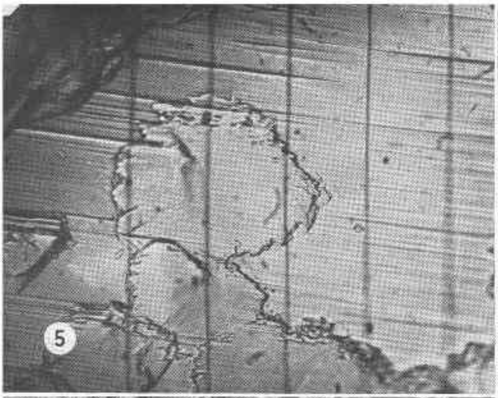
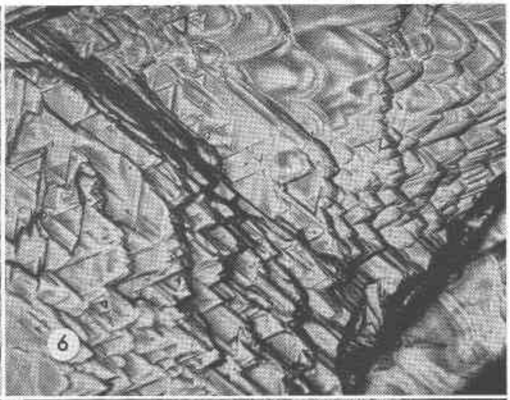
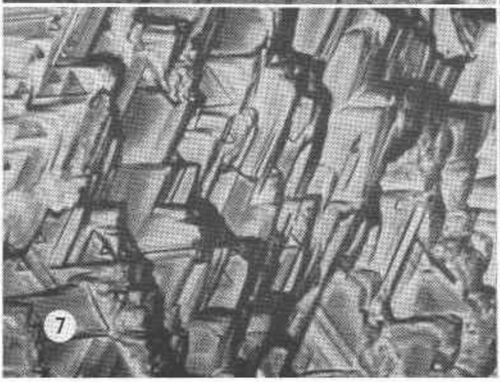



FIG. 1. Usual trigons (×350).
FIG. 2. Trigons in broken condition (×100).
FIG. 3. Irregular shaped isolated figures (×55).
FIG. 4. Features of Fig. 3 on a magnified scale (×350).

*Observations on crystal No. 15.* This crystal is a broken octahedron. On all natural octahedral faces trigons were observed. The broken face is a cleavage face, and we will describe fully the features observed only on this face, as they are of more importance in the present investigation. Thus Fig. 8 represents the photomicrograph of the cleavage face in which the zigzag cleavage lines are clearly seen. Figure 9 represents another region on the same face in which the ring cracks similar to those reported by Patel and Tolansky (1957) are clearly observable, whereas Fig. 10 represents another region of the same face in which the block pattern is visible. A careful study of the block pattern reveals that there exist in the same picture a few isolated triangular markings. It was verified that these triangular markings are depressions and that they have the same orientation as the trigons on the natural octahedral faces. In fact they are identical with the trigons observed on natural (111) faces.







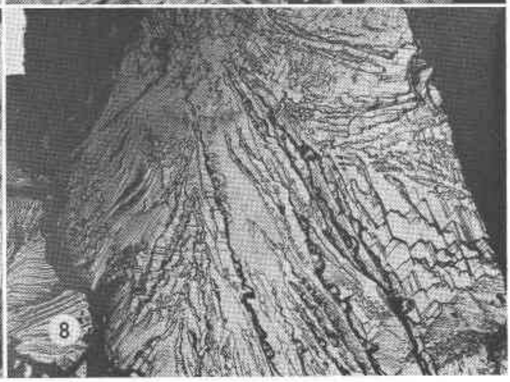



FIG. 5. Multiple light profile running over the features of Fig. 4 (×350).
FIG. 6. Trigons and the block pattern (×500).
FIG. 7. Block pattern (×500).
FIG. 8. Cleavage face with zigzag cleavage lines (×350).

*Observations on crystal No. 10.* This is also a crystal of octahedral habit having natural octahedral faces. Examination of the various faces revealed that one of these faces was chipped. We will describe here only observations made on this region of the crystal, as it is useful in drawing our conclusions. Thus Fig. 11 represents the portion of the chipped off face. The vertical lines on which the rows of trigons are situated appear to be cleavage lines. The rows of trigons are situated on the cleavage lines. The characteristics of these trigons are similar to those on the other natural octahedral faces of this crystal. Figure 12 represents a part of this face magnified. Trigons are clearly visible in this figure and they resemble closely the trigons on the natural (111) faces. Figure 13 represents another region in which some of the trigons in rows along the cleavage lines appear to have some of their sides broken. Figure 14 represents the etch pattern along the cleavage lines of a cleavage face of calcium fluoride

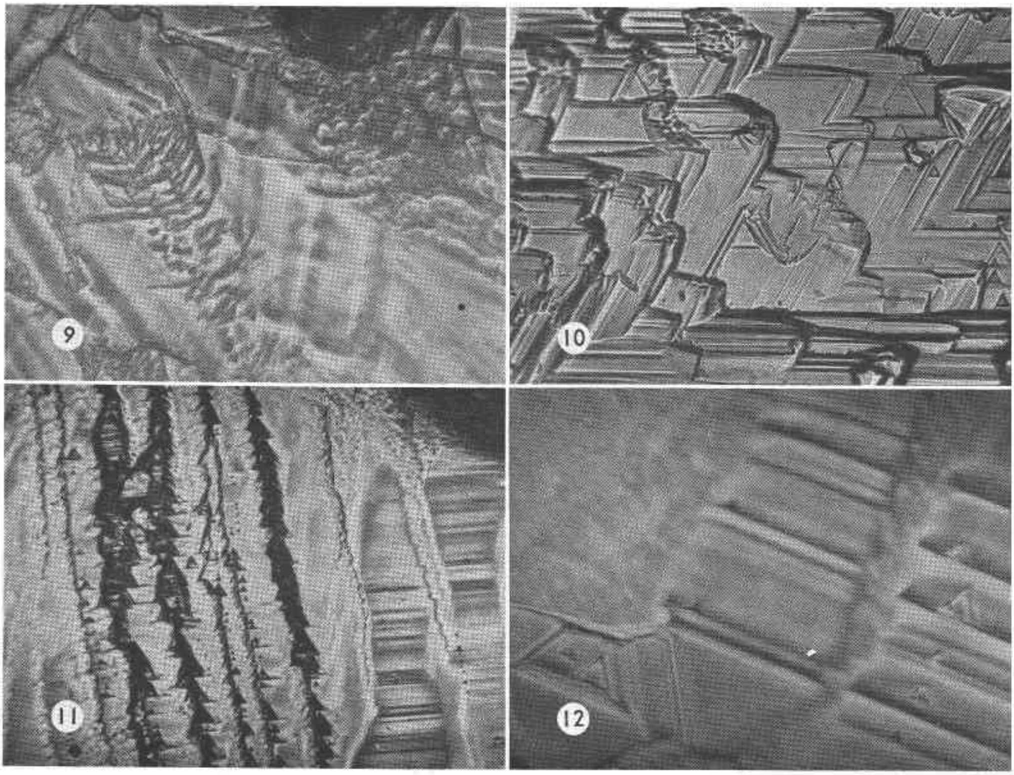


FIG. 9. Ring cracks (×430).
FIG. 10. Block pattern with isolated triangular markings (×350).
FIG. 11. Trigons on cleavage lines (×100).
FIG. 12. Portion of Fig. 11 on a magnified scale (×1600).

etched in 0.2N $HNO_3$ for one hour. All triangular markings in this figure are depressions, and some of their sides are broken. The pattern observed on diamond octahedral face in Fig. 13 and the pattern produced by etching the (111) cleavage face of calcium fluoride are very similar.

*Observations on crystal No. 11.* A large number of such crystals were studied. They are all dodecahedra having rounded faces. We therefore describe the pattern only on crystal No. 11, which is representative. Figure 15 represents the photomicrograph of the pattern observed on the dodecahedral faces. The pattern consists of elevated microdiscs as observed by Pandeya and Tolansky (1961).

## CONCLUSIONS

The observations made on crystal No. 4, namely, that on different

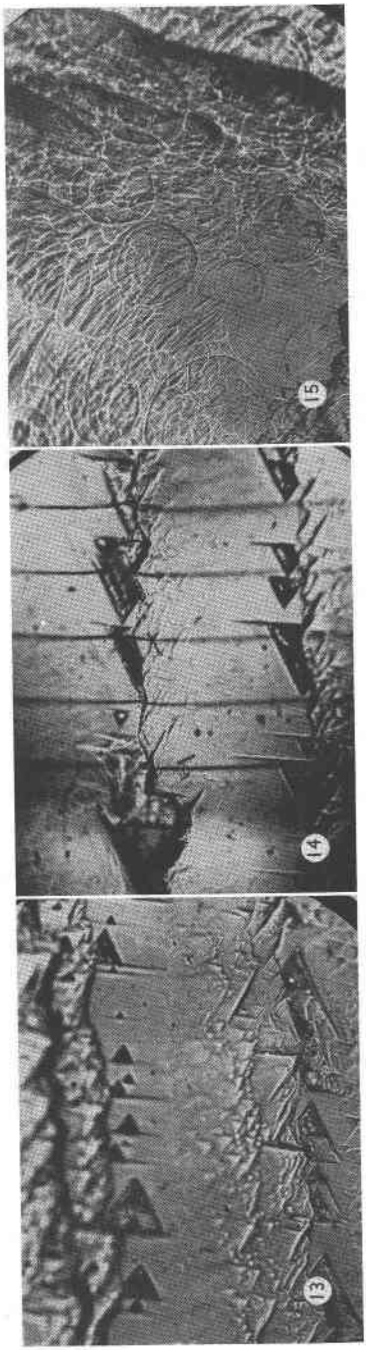



FIG. 13. Trigons on rows along the cleavage lines (×350).
FIG. 14. Etch pattern along the cleavage lines on the cleavage face of a calcium fluoride crystal (×350).
FIG. 15. Elevated micro-disk patterns (×100).

faces of the same crystal, there exists simultaneously trigons, a block pattern and an elevated microdisc pattern, are very helpful in deciding the origin of trigons observed on the natural (111) faces of diamond. The block pattern as reported by Omar *et al.* (1954) can be produced by strongly etching the (111) faces of diamond. The elevated microdisc pattern observed by Pandeya and Tolansky (1961) on the dodecahedral faces of diamond is explained as having been formed by natural solution. No one has reported the existence of such pattern on the (111) faces of diamond. However Patel and Goswami (1962) have produced such patterns on the various faces of topaz. They have experimentally established that the microdisc pattern can be produced on any face of the crystal, if the proper conditions of etching are devised. It is therefore conjectured that this crystal might have been subjected to rapid etching in nature, which produced the observed microdisc and block patterns. The trigons on some of these faces might have also been formed during this etching. This conjecture is further supported by the observations made on crystals No. 15 and No. 10. In crystal No. 15 the block pattern, the ring cracks and the trigons were observed on the same cleavage face. The ring cracks as reported by Patel and Tolansky (1957) and the block pattern as reported by Omar *et al.* (1954) were developed when the crystal face was etched. The existence of the ring cracks and the block pattern on the same face therefore suggests that the face under investigation might have been subjected to solution in nature and hence the trigons which are observed in the block pattern and on this face might have been formed by etching. The experimental observations that rows of triangular pits similar to those observed on the cleavage lines of the natural octahedral faces of diamond can be produced on the cleavage lines of the octahedral faces of a calcium fluoride crystal by etching suggest that the rows of pits observed on the cleavage lines on the (111) cleavage faces of diamond might have been formed by solution in nature. The observations made on the microstructures on the faces of various crystals therefore suggest that Panna crystals may have been subjected to severe etching in nature and the trigons observed on the octahedral faces of these crystals might have been formed as a result.

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