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STUDIES ON THE DODECAHEDRAL FACES OF DIAMOND

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ABSTRACT

The dodecahedral faces of diamond have been examined by optical and electron microscopy. The electron micrographs have revealed alternately bright and dark bands formed due to the shadow of the ruts and ridges. Triangular depressions have been observed in the region of these bands and it is noted that the triangular depressions in the bright bands are oriented opposite similar features in the dark bands. It is conjectured that the bright and dark bands represent (111) and ($\bar{1}$11) planes. The intersections of these planes make the ridges and ruts associated with the striations observed on the dodecahedral faces of diamond. The implications are discussed.

INTRODUCTION

There exists extensive literature dealing with the morphology and topography of octahedral and cubic faces of diamond. It appears that the dodecahedral faces have not been studied so extensively. This may be because most diamonds mined are octahedra. Dodecahedra with plane faces are found only occasionally.

Some structural characteristics of natural dodecahedral faces have been reported by Fersmann and Goldschmidt (1911), Sutton (1928), Williams (1932) Emara and Tolansky (1956), Pandeya and Tolansky (1961) and Varma (1967). Fersmann and Goldschmidt (1911) from their studies on the dodecahedral form of diamond consider that it is due to a solution process. Sutton (1928) has reported that the dodecahedral faces of diamond are generally markedly striated, with striations running parallel to the long axis of the rhomb. Williams (1932) showed micrographs of dodecahedral faces. Some show striations and others a flaky appearance. Emara and Tolansky (1956) made a detailed study of dodecahedral faces using precision multiple beam interferometry and reported that the striations are narrow shallow ruts, often less than 50 Å deep. They also showed the existence of network pattern on these faces which they interpreted as a result of some natural dissolution process. They concluded that the dodecahedral faces appear to be more subject to natural dissolution than the octahedral faces.

It thus appears that though the existence of striations on dodecahedral faces and their structure have been reported by the investigators mentioned, no one has investigated the more subtle problem of their mechanism of formation. This may be due to the limited resolution, about one micron, of the optical microscopes with which they were studied. We have an electron microscope with resolving power of about 20 Å in extension, and Patel and Patel (1968) have developed a technique for preparing replicas of diamond surfaces. We have employed this technique to reveal subtle microstructures on various faces of diamond and other mineral crystals. We report here the structure of the striated dodecahedral faces of diamond as revealed by electron microscopy.

Experimental

An approximately 1.5 carat slightly transparent diamond octahedron, with small dodecahedral faces on its twelve edges was selected for this study.

The small dodecahedral faces were first studied by optical microscopy and then single-stage carbon replicas were made of the regions of interest by the method of Patel and Patel (1968). The replicas were investigated by transmission electron microscopy. The replicas made with great difficulty because of the roughness of the striated faces.

Observation and Results

Figure 1 represents the optical photomicrograph of the dodecahedral face in which the striations parallel to the longer diagonal of the rhomb are clearly seen. In order to investigate whether there are any microstructures on the faces forming the ruts, the crystal was tilted so that the axis of the microscope became perpendicular to one of the two octahedral faces forming the octahedron edge. Figure 2 is an optical photomicrograph revealing the microstructures on one of the faces forming the ruts. The striations are seen in the figure. It is interesting to note that trigons are observed on the face indicating that the face forming the ruts is an octahedral face. This would seem to indicate it to be a projection of one of the octahedral sheets which are piled up one over the other during the growth of the octahedron.

In order to investigate the region within the ruts with better resolution, a replica of a small region of the striated face was prepared and examined

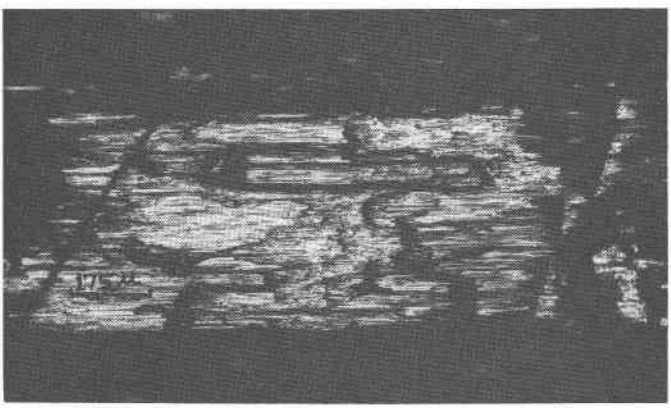

FIG. 1. Striations on the dodecahedral face of diamond.

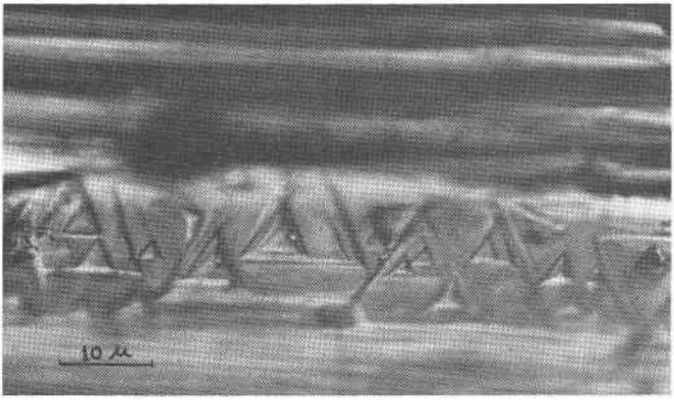

FIG. 2. Microstructure on dodecahedral face revealing the ruts and ridges.

in the electron microscope in transmission. Figure 3 represents the electron micrograph of this replica. It may be mentioned that the grain-like structure of this photomicrograph is due to coagulation of the shadowing material. It is seen that the electron micrograph consists of bands of alternate brightness and darkness. These represent the shadows of the ridges and ruts of the striations on the face. The intersections of these bands, which are strictly rectilinear running in ⟨110⟩ directions, are the edges of the ruts and the ridges constituting the striations.

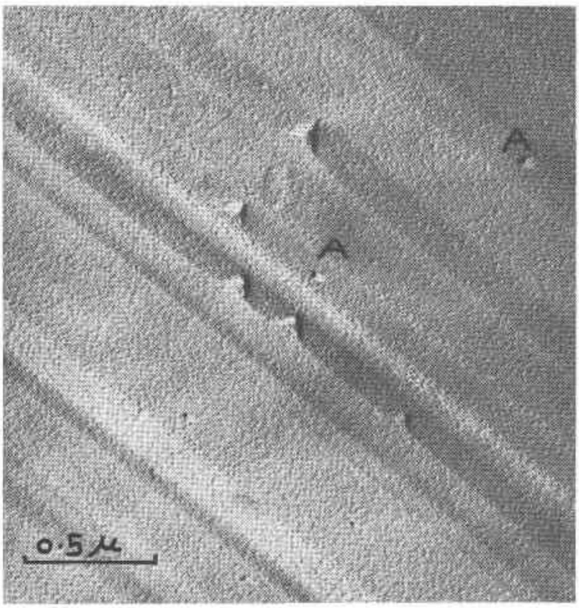

FIG. 3. Electron micrograph revealing the bright and dark bands.

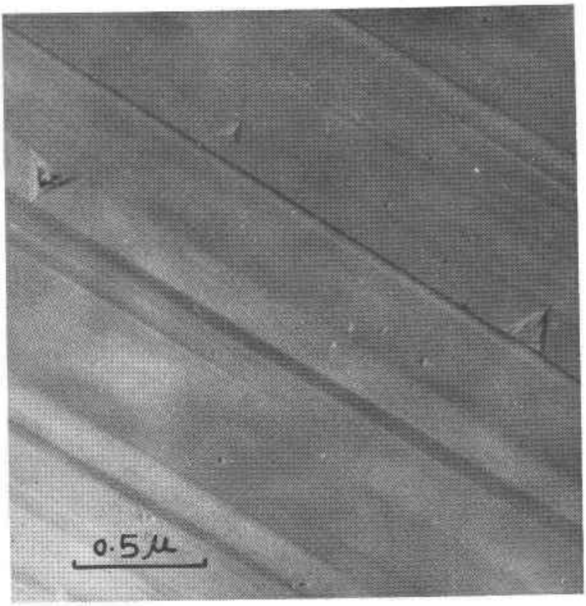

FIG. 4. Striated region on another (110) face.

A point of interest is the appearance of the triangular markings in Figure 3. They are strictly crystallographically oriented in the same way with their sides in ⟨110⟩ directions. It may be noted that these triangular markings all appear in the dark band and none were found in the bright bands of the picture. The shadows of these features are in opposite direction to the shadow of a dust particle (mark A) on the face, revealing that they are depressions since the dust particle is an elevation on the surface.

Figure 4 represents an electron micrograph of a striated region on another (110) face of the crystal. This micrograph also has characteristics similar to those observed in Figure 3. The only difference between the two electron micrographs is that in this figure the triangular depressions are in dark as well as in bright bands. The orientation of the triangular depressions in bright bands is opposite the orientation of those in the dark band. The region of dark and bright bands thus represents any two of the 111 planes. Since the orientations are opposite each other, one region may represent (111) plane and the other $(\bar{1}11)$. The intersections of the bright and dark bands thus represent the intersections of (111) planes with $(\bar{1}11)$ planes. The electronmicrograph in Figure 5 reveals two triangular depressions oppositely oriented on the two sides of the intersection of a bright and dark band confirming that the bright and the dark band represent (111) and $(\bar{1}11)$ planes respectively.

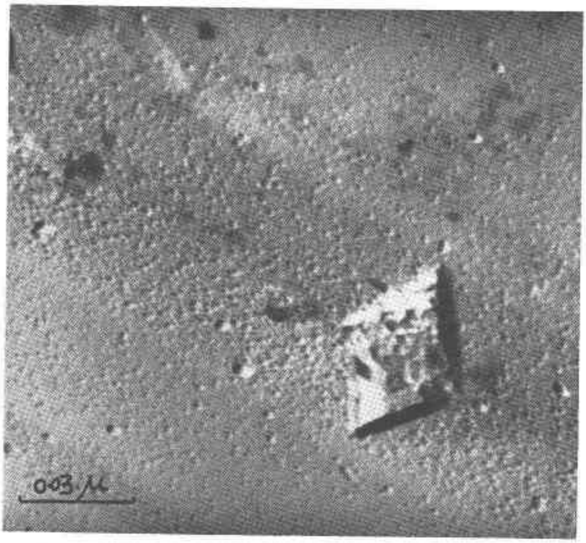

FIG. 5. Two triangular depression oppositely oriented.

CONCLUSIONS

The structure of the (110) planes of diamond and the formation of the striation on these faces is now apparent. During growth of the crystal, the (110) faces are formed along with the other faces depending on the conditions controlling the morphology of the crystals. Once these faces are formed, they might be subjected to subsequent dissolution as reported by investigators such as Fersmann and Goldschmidt (1911), Frank and Puttick (1958) and Tolansky (1959). As (110) faces are more susceptible to dissolution (Tolansky and Emara, 1956) they will be etched, and etching will proceed in such a manner that after dissolution (111) faces will be exposed. The adjacent (111) and ($\bar{1}$11) faces thus form the ruts and ridges. That the striations consisting of the ruts and the ridges are formed due to the intersections of alternately (111) and ($\bar{1}$11) planes is supported by the triangular depressions and their orientations observed on the faces binding the ruts and the ridges. The electron microscopic examination has provided a magnified view of the structure of striations on (110) faces of diamond. The observations reported above suggest that the trigons are formed due to post-growth dissolution of the octahedral faces.

REFERENCES

EMARA, S. H. AND S. TOLANSKY (1956) The microstructures of dodecahedral faces of diamond. *Proc. Roy. Soc., (London)* **A239,** 289–295.

FERSMANN, A. AND V. GOLDSCHMIDT (1911) *Der Diamant.* K. Winter, Heidelberg.

Frank, F. C. and K. E. Puttick (1958) Etch pits and trigons on diamond: II. *Phil. Mag.* **3,** 1273–79.

Pandeya, D. C. and S. Tolansky (1961) Micro-disk patterns on diamond dodecahedra. *Proc. Phys. Soc. (London)* **78,** 12.

Patel, A. R. and S. M. Patel (1968) Rapid method of preparing single stage carbon replica for electron microscopy of some mineral crystals. *Rev. Sci. Inst.* **39,** 409–410.

Sutton, J. R. (1928) *Diamond.* Thomas Murby and Co., London.

Varma, C. K. R. (1967) Studies on natural diamonds of the dodecahedral form. *Phil. Mag.* **16,** 621–634.

Tolansky, S. (1959) Diamond dodecahedral, some new observations. *Ind. Diamond Rev.* **19,** 6–13.

Williams, A. F. (1932). *The Genesis of Diamond.* Benn, London.

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