ON A GROOVED PENTAGONAL DODECAHEDRON OF PYRITE

BY

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(With plates 18 and 19).

I. ON CRYSTALS OF THE NOTCHED OR GROOVED TYPE.

Crystals of the notched or grooved type are known from some minerals which crystallise in the cubic system.

From *diamond* grooved octahedrons are known, whose grooves remind us of octahedral faces, or the faces of triakis octahedra or hexakis ostahedra. From *haüynite* too grooved octahedrons are pictured, whose grooves are bordered by octahedral faces. Grooved *analcite* is known in icositetrahedrons, the grooves are bordered by faces of the same icositetrahedron.

1. Grooved diamond.

In crystallography there are few domains where such a confusion and indistinctness reigns as in the discussion of the grooved diamonds (fig. 1), which are connected with twinning, and with the problem whether diamond crystallyses holohedrally or hemihedrally. TUTTON (1922, Vol. I, p. 501—502) writes: "The "notched" or grooved type of twin is very well shown by the diamond, a complementary pair of positive and negative tetrahedra, or of

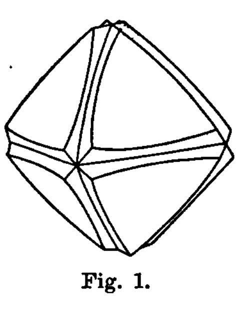

Fig. 1.

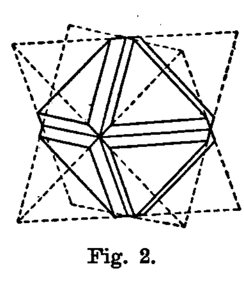

Fig. 2.

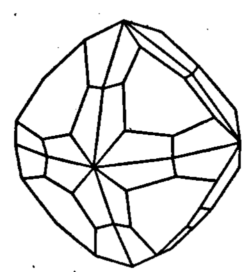

Fig. 3.

hexakis tetrahedra, twinned about a cube face, interpenetrating to produce an apparent octahedron or hexakis octahedron, but with more or less deep grooves along the octahedral edges, owing to the interpenetration not being absolutely complete. Two such diamonds are represented at (a) and (b) in Fig. 397" (our figures 2 and 3).

In his fig. 397 (a) (our fig. 2) a "complementary pair of positive and negative tetrahedra" is indeed marked by dotted lines, but with this the grooved octahedron is by no means explained, as the two interpenetrating tetrahedra are meanwhile altered into octahedra.

From the chapter "Historisches zur Hemiedrie und Zwillungsbildung" from FERSMANN and GOLDSCHMIDT's "Der Diamant" (1911, p. 65—70) it follows, that MOHS was the first, who in 1824 connected the grooved diamonds with twinning and with the hemihedral character of diamond, but without explaining how this must be imagined.

It seems that a number of mineralogists borrowed this way of looking at our problem, as HAIDINGER (1825), NAUMANN (1828 and 1830), ROSE (1843), BREITHAUPT (1847), MILLER (1852), till in our days TUTTON (1922), and for the mineral haüynite JAEGER (1924, p. 179).

If one wishes to connect the three phenomena: grooved octahedra, twinning and the hemihedral character of the mineral, it could be done in the following way:

A complementary pair of positive and negative tetrahedra have formed a composite crystal, being an octahedron with four smaller triangular faces and four greater hexagonal faces; this composite crystal is an instance of "supplementary twinning" (TUTTON, 1922, I, p. 505). Two of these feigned octahedra are twinned about a cube face and interpenetrate to produce an octahedron with grooved edges.

If we consider diamond to belong to the holohedral class of the cubic system, the cube face can no longer be looked upon as a twin plane, and with that every connection between grooved octahedra and a law of twinning disappears.

Before MOHS had connected the grooved diamond octahedra with twinning, BOURNON had already given an other explanation of the grooved diamonds: "Que la plupart des angles rentrants sont un produit direct des lois de reculement de la cristallisation et n'appartiennent nullement à autant de macles" (Catalogue de la collection minéralogique particulière du roi, Paris, 1817; cited after FERSMANN and GOLDSCHMIDT, 1922, p. 66).

This quotation moreover proves, that before 1817 already a connection between the grooved character of some octahedra and twinning was sought after. Presumably it was ROMÉ DE L'ISLE, who did it for the first time in his "Crystallographie ou description des minéraux, Paris, 1783".

FERSMANN and GOLDSCHMIDT are in accord with BOURNON, where they write (1911, p. 68): "Die einspringenden Oktaederkanten bedürfen zu ihrer Erklärung nicht der Hemiedrie. Sie sind durch Zurückbleiben im Wachstum und durch Lösung verständlich". But these authors are convinced that diamond crystallises in a hemihedral class and write (1911, p. 23): "Die Untersuchung hat dazu geführt, die Hemiedrie *streng* und *unzweideutig* nachzuweisen. Sie erscheint somit als gesichert", and p. 68: "Die Hemiedrie ist als eine schwache anzusehen, d.h. der Unterschied zwischen den beiden Tetraedern ist nicht gross". This monograph on diamond by FERSMANN and GOLDSCHMIDT turned out to be a failure, partly because the authors have attached an exaggerated value to their "Reflexbilder", partly because GOLDSCHMIDT has set up an unfortunate theory on simultaneous growth and solution of diamond, which saturates their whole work.

Meanwhile A. L. W. E. VAN DER VEEN (1911 and 1913) had proved, that diamond is physically holohedral, as the trigonal axes lack every trace of polarity, whereas W. H. BRAGG and W. L. BRAGG (1915) have demonstrated the same fact, by determining the structure of diamond with X-rays.

J. R. SUTTON (1928) as well as A. F. WILLIAMS (1932) arrived at the conclusion that diamond crystallises in the holohedral class of the cubic system, after studying a large number of diamonds. NIGGLI (1927, p. 33) leaves it undecided whether diamond belongs to the holohedral or to a hemihedral class and thinks that the grooved edges may possibly be attributed to solution. This however is improbable as is evident from WILLIAMS' monograph. Just as VAN DER VEEN, WILLIAMS concludes that the grooved diamond octahedra are the result of a particular process of growth. VAN DER VEEN explains all irregularities of diamond crystals, expressly their rounded faces and their grooved edges, by supposing growth in sheets parallel to the octahedral faces, whereby the grooves are sometimes bounded by octahedral faces but as a rule by arbitrary faces.

Finally it must be pointed out, that the grooved pentagonal dodecahedron of pyrite, which is described below, proves, that twinning and a hemihedral character has nothing to do with it, since a pentagonal dodecahedron is a hemihedral form, from which it is impossible to derive another hemihedron.

2. Grooved haüynite.

W. F. FORD (DANA-FORD, 1932) gives on p. 187 a picture of a grooved octahedron of haüynite, of which he writes: "Fig. 431 is a repeated octahedral twin of haüynite" (See our fig. 4).

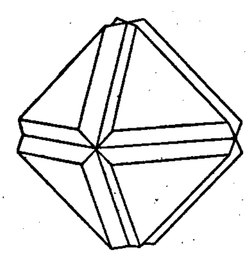

Fig. 4.

F. M. JAEGER (1924, p. 179) understands these crystal as a twin, with the cube as twin plane, whereby haüynite is consequently supposed to crystallise in the hexakis tetrahedral class. An explanation of this composite twin will probably have to be given as we did for the same form of diamond.

3. Grooved analcite.

DANA-FORD (1932, fig. 411, p. 121) gives a picture (our fig. 5) of a grooved icositetrahedron, of which it is written, on p. 652, that this mineral appears "sometimes in composite groups about a single crystal as nucleus". F. M. JAEGER (1924, p. 172—173) observes in connection with this form: "In this respect the appearance of re-entrant angles of a twin — a fact, on which particular stress is sometimes laid, as a criterion for existing twin formation — is a circumstance, which must be considered with the requisite caution. Thus the crystal of analcite, pictured in fig. 354" (our fig. 5) "is well set up with re-entrant angles, and it could be confounded at first sight with a twin crystal. In reality however one has to do here with nothing else than a parallel growth, after the three cube faces, of some incositetrahedral shaped individuals".

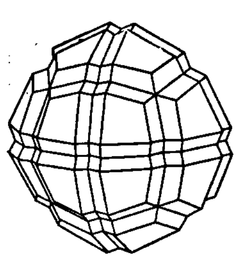

Fig. 5.

Next to this geometrical interpretation we can place another one, by which the natural process of growth is chosen as starting-point. Such a grooved icositetrahedron is formed by growth in layers of the icositetrahedral faces, whereby, from a given moment in the process of growth, the sheets become uniformly smaller or keep a constant area.

4. Grooved pyrite.

As a new form of a mineral with grooves, in the place of edges, a pentagonal dodecahedron of pyrite is described below (fig. 8).

II. DESCRIPTION OF A PYRITE PENTAGONAL DODECAHEDRON WITH GROOVED EDGES.

(Plates 18 and 19).

The "Nieuw Guinea Expeditie" of the "Koninklijk Nederlandsch Aardrijkskundig Genootschap", in the years 1939 and 1940, brought 57 crystals of pyrite from the basin of the Mapia-river in Netherlands South New Guinea, which were collected by the leader of the expedition "Mr. C. C. F. M. LE ROUX", Keeper to the "Rijksmuseum van Volkenkunde te Leiden" and by the geologist of the expedition Dr. Ir. R. IJZERMAN. Nearly all these pyrites were obtained from natives, who bear them as talisman in their portable nets, through which the sharp edges and summits are more or less worn down. A short description of these pyrites will follow in a separate publication.

Here follows a description of the most interesting of these crystals, which has a greatest dimension of about 3 cm. It is a composite crystal (fig. 6 and plate 18 fig. I) existing of three pentagonal dodecahedrons I,

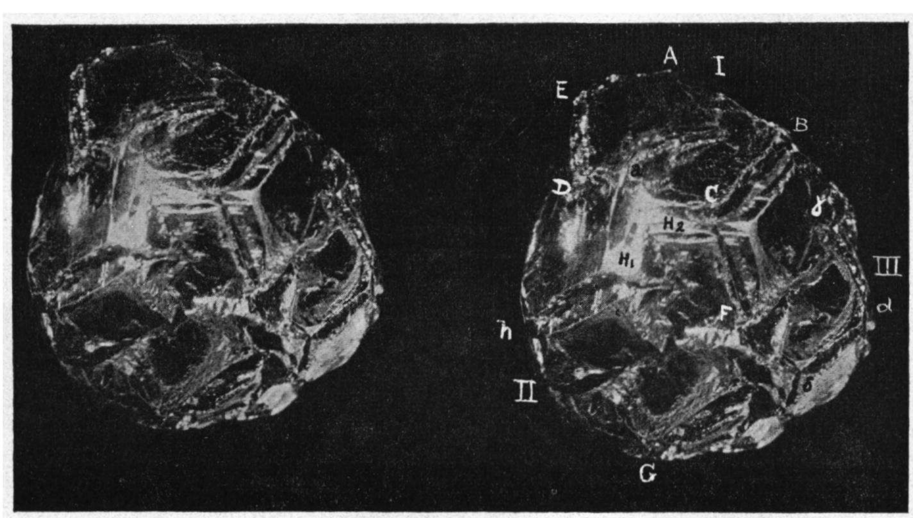

Fig. 6.

II and III, of which I and II form an *iron cross* twin, which is easily recognized by the fact, that they have a common cube face, which is partly striated vertically (fig. 6: H_1), partly horizontally (fig. 6: H_2). The third crystal III has an arbitrary orientation with regard to the twin I—II.

Besides the pentagonal dodecahedral and cube faces, some octahedral faces with a splendent lustre appear, as in fig. I near E, B, F, h and δ and in the figures II, IV and V indicated by O.

The most remarkable fact about this composite crystal is, that the edges of the pentagonal dodecahedron are replaced by grooves. These grooves are partly bordered by crystallographic faces and as such formed by growth. An examination on the goniometer by Mr. N. HEERTJES demonstrated, that the original grooves are bordered by narrow faces of the pentagonal dodecahedron $\{210\}$. But moreover these grooves are affected by etching, by which they are deepened in the form of a canyon. A section, perpendicular to the edge [010] lookes like fig. 7.

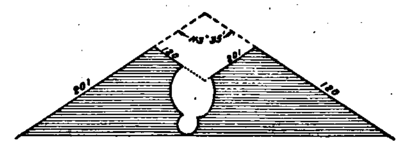

Fig. 7.

The corroded grooves were originally filled with *dolomite,* whereas these pyrites from New Guinea, with pentagonal dodecahedral habit, occur in limestone. So the habit of these grooved pyrite pentagonal dodecahedrons looks, without etching phenomena, as pictured in fig. 8.

Fig. II shows the environs of the octahedral face B, projected on this face.

Fig. III represents the surroundings of the summit C, with grooves in the directions of B and F and in the cube face. From above in the figure downward there follows on the face 120 first a worndown edge e—f, then to the left a strip from the face 201 from a to b, and to the right a strip from the face $20\bar{1}$ from f to g; further follows to the left the corroded part of the groove from b to c, of which the counterpart to the right lies behind the face $20\bar{1}$. The cube face 100 is also affected by corrosion. Part of it lies in the form of an equilateral triangle between the strips a—b and f—g. Between the two pentagonal dodecahedral faces 200 and $20\bar{1}$ lies the main part of the face 100, which is cognizable by the striation; in its midst there is a deep groove and to its right a shallow one.

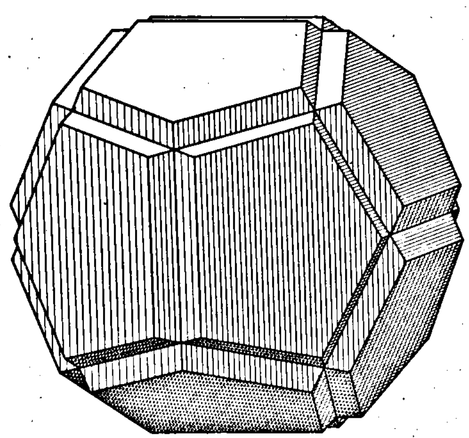

Fig. 8.

Fig. IV (plate 19) gives a general view of the most important part of the crystal III with octahedral faces near δ and κ. As the summit F from the crystal I lies near the summit δ from III, the situation is here rather intricate; this is pictured in fig. V. Here F from fig. I is replaced by F_1 and F_2. From F_1 runs a corroded groove in the direction of C, whereas from F_2 one runs toward G. From the complex of the three facelets O near δ grooves run toward α, ε and ω, moreover a deep groove runs between face 102 from III and face (120) from I. This latter groove is wholly due to corrosion, and is not accompanied by remainders of crystal faces.

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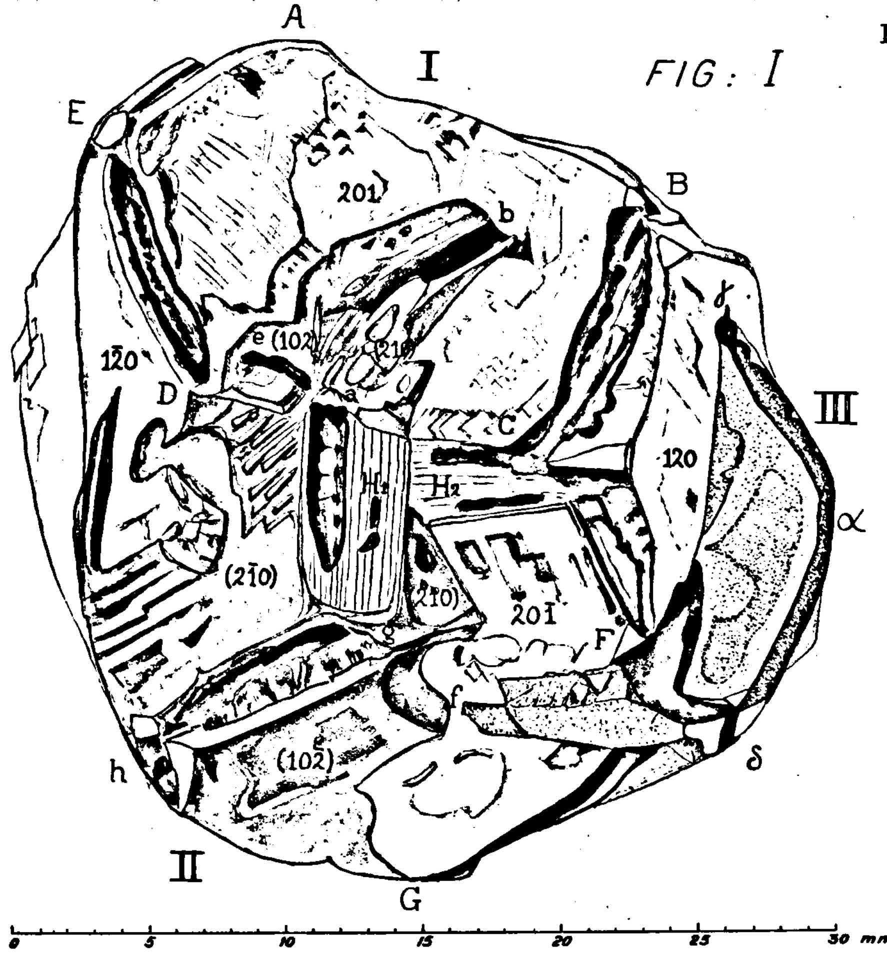
FIG: I



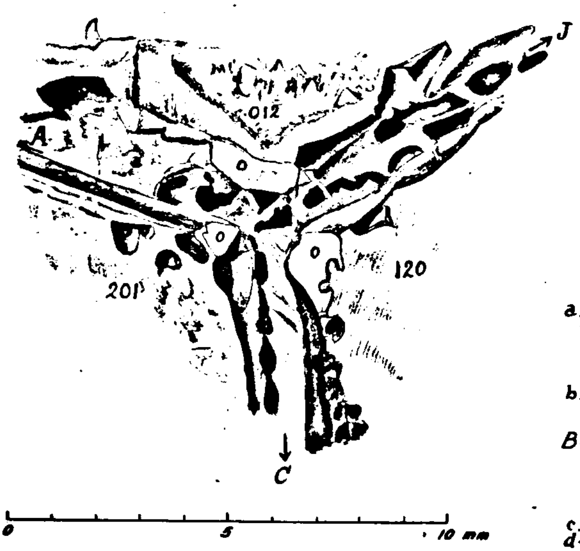


FIG: II

FIG: III

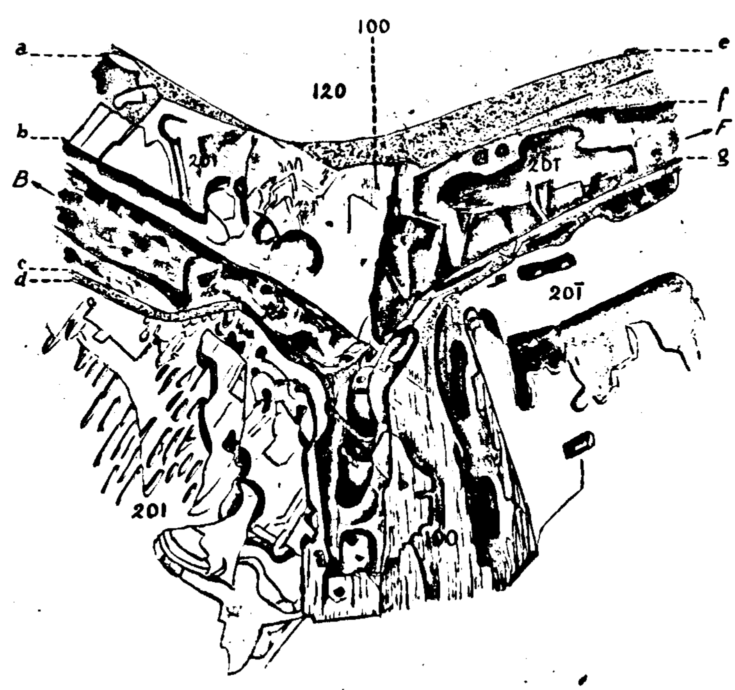


PLATE XIX.

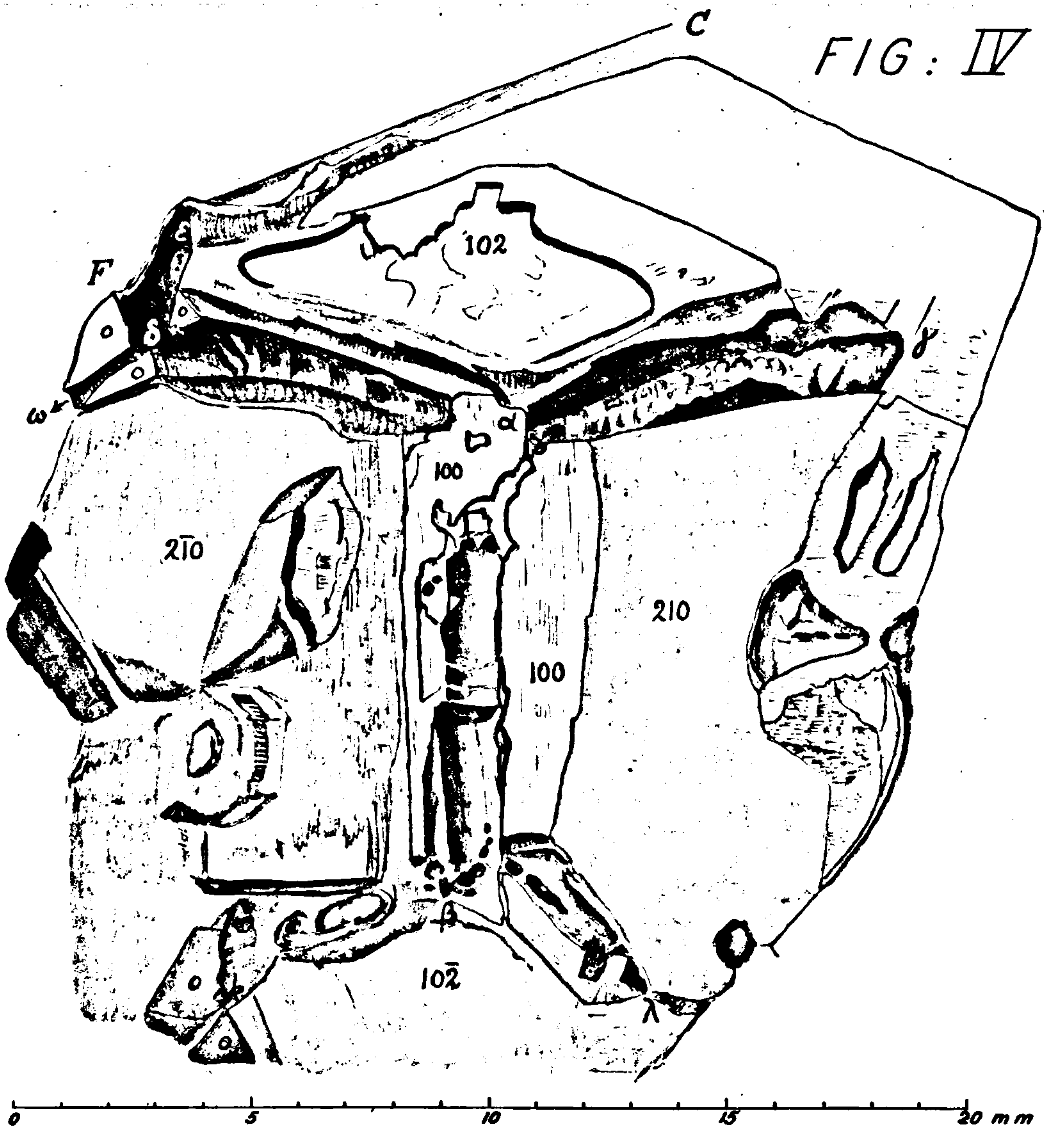


FIG: IV

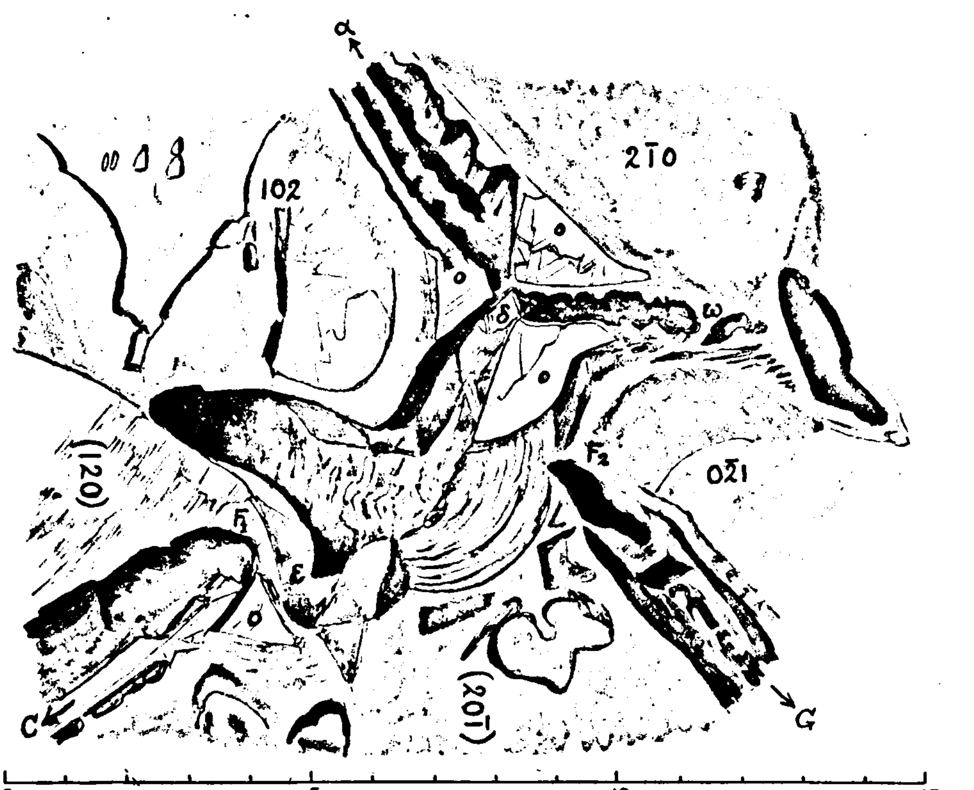


FIG: V