

Citation:

Haga, H. & F.M.Jaeger, The Symmetry of the Röntgen-patterns of Monoclinic Crystals, in: KNAW, Proceedings, 18 II, 1916, Amsterdam, 1916, pp. 1201-1205

Physics. — “*The Symmetry of the Röntgen-patterns of Monoclinic Crystals.*” By Prof. H. HAGA and Prof. F. M. JAEGER.

(Communicated in the meeting of Jan. 29, 1916).

§ 1. In the following pages we publish the results, which were obtained by radiating through planeparallel plates of *monoclinic* crystals.

As is well known, the monoclinic system possesses *three* classes of symmetry. The crystals of the *sphenoïdical* class only have a polar binary axis as their single symmetry-element; those of the *domatic* class only a single symmetry-plane; and those of the *prismatic* class are in possession of a plane of symmetry, a binary axis perpendicular to it and a symmetry-centre. According to the now adopted theory of the diffraction-phenomenon here considered, a symmetry-centre is added to the elements of symmetry of the crystal already present. And just because the simultaneous presence of each pair of the three elements of symmetry here to be considered, necessarily involves the presence of the third of them, the crystals of each of the three classes mentioned will thus behave with respect to the symmetry of their Röntgen-patterns, as if they belonged to the monoclinic-prismatic class: for here are the three elements of symmetry mentioned above, exactly combined. Thus, indifferently to which of the three said classes a monoclinic crystal will belong, its Röntgen-pattern for a section parallel to {100} or {001} must always show *one single plane of symmetry*, while for a section parallel to {010} only *a single binary axis*, perpendicular to the photographic plate will manifest itself. By the investigations described in this paper, we have brought full proof of the exactitude of these conclusions.

§ 2. As representatives of the different classes of symmetry, we have studied the following crystals:

a. Of the *monoclinic-sphenoïdical* class: *dextrogyratory tarttric acid*, *cane-sugar* and *dextrogyratory rhamnose*.

b. Of the *monoclinic-domatic* class: *scolezite*.

c. Of the *monoclinic-prismatic* class: *gypsum*, *epidote*, *amphibole* and *augite*.

I. *Monoclinic-sphenoïdical class.*

Plates parallel to {100}, {010} and {001} were cut from some beautiful, transparent crystals of *dextrogyratory tarttric acid*: $C_4O_6H_6$, whose axial ratio is: $a : b : c = 1,2747 : 1 : 1,0266$, and $\beta = 79^\circ 43'$. The crystal-plate parallel to (100) had a thickness of 1,08 mm., that parallel to (010) of 1,15 mm., and the plate parallel to (001) of 1,18 mm.

Although the obtained patterns were very regularly built, they appeared to be too feeble for immediate reproduction. However, in fig. 1 to 3 of Plate VI their stereographical projections are published.

In a quite analogous way crystals of *cane-sugar*: $C_{12}H_{22}O_{11}$ were studied; their parameters are: $a : b : c = 1,2595 : 1 : 0,8782$, and $\beta = 76^{\circ}30'$. In the case of the crystal-plate parallel to (100) the thickness was: 1,86 mm.; that parallel to (010) was 1,88 mm., and that parallel to (001) was 1,81 mm. thick. The obtained photos are reproduced in fig. 1 to 3 of Plate I, and in stereographical projection in fig. 4, 5, and 6 of Plate VI.

From an aqueous solution of *d-rhamnose*, magnificent lustrous and faultlessly shaped crystals were obtained, and here also plates parallel to the three pinacoides were cut out of them. The axial ratios of these crystals, whose chemical composition is: $C_6H_{12}O_6 + H_2O$ (mpt: $93^{\circ} C.$), were: $a : b : c = 0,9998 : 1 : 0,8435$, and $\beta = 84^{\circ}35'$. The crystal-plate parallel to (100) had a thickness of 1,91 m.m.; that parallel to (010), of 1,95 m.m., and that parallel to (001) of 1,93 m.m. The obtained patterns are reproduced in fig. 4 on Plate I, and in fig. 5 and 6 on Plate II; their stereographical projections in fig. 7, 8, and 9 on Plate VI.

From all these experiments it can be clearly seen, that notwithstanding the fact, that these crystals possess only a single binary axis, their RÖNTGEN-patterns parallel to (100) and (001), however, always manifest a plane of symmetry, while that parallel to (010) shows a binary axis, manifesting itself in the image as a centre of symmetry. Thus it is proved, that these patterns possess the same symmetry, as if they were obtained with monoclinic-prismatic crystals.

§ 3. II. *Monoclinic-domatic Class.*

After many tentatives we were able to get some crystal-plates from a small, simple *scolezite*-crystal from *Teigarshorn* in *Iceland*. It is very difficult to find crystals of this mineral, — whose composition is: $CaAl_2Si_2O_{10} + 3H_2O$, and whose axial ratio is: $a : b : c = 0,9764 : 1 : 0,3434$, with $\beta = 89^{\circ}18'$, — which appear not to be twins or multiplex crystals. The thickness of the small plates was as follows: for that parallel to (100), it was 0,78 m.m., for that parallel to (010) 0,76 m.m., and for that parallel to (001), 0,83 m.m.

Of the resulting photograms we have only reproduced here the image parallel to (001), in fig. 7 and Plate II, while the corresponding stereographical projections are reproduced in fig. 10 and 11 on Plate VI.

Notwithstanding the close approximation of the symmetry of this

mineral to that of a rhombic crystal, its monoclinic symmetry, however, is shown very clearly in the resp. RÖNTGEN-patterns. Also in this case the symmetry of the RÖNTGEN-images is quite in agreement with the conclusions drawn from the theoretical views.

§ 4. III. *Monoclinic-prismatic Class*. Three plates parallel to (100), (010), and (001) were cut out of a beautiful crystal of *gypsum* from *Bun Abis, S.W. Africa*; their thickness was resp. 0,71, 0,89 and 0,75 mm. The parameters of this compound are: $a : b : c = 0,6895 : 1 : 0,4132$, and $\beta = 81^{\circ}2'$. The obtained RÖNTGENogrammes are reproduced in fig. 9 to 11 on Plate III, and in stereographical projection in fig. 12, 13 and 14 on Plate VI.

In the same way three plates parallel to (100), (010) and (001), whose thickness was respectively 1,02, 1,00 and 0,93 mm., were cut from a beautiful crystal of *epidote*: $\text{Ca}_2\text{HAl}_3\text{Si}_3\text{O}_{13}$. The parameters of this mineral originating from *Untersulzbach*, are: $a : b : c = 1,5807 : 1 : 1,8057$, and $\beta = 64^{\circ}36'$. The resulting photos are reproduced in fig. 12 on Plate III, and in fig. 13 and 14 on Plate IV; while in fig. 15, 16 and 17 on Plate VI their stereographical projections are given.

In this case as well as in both the foregoing, the patterns of crystal-plates parallel to (100) and (001) only show a single plane of symmetry; those corresponding with sections parallel to (010), a single binary axis perpendicular to the photographic plate. This is in full agreement with the theoretical expectation; also in these cases the observed symmetry of the RÖNTGEN-patterns thus appears to agree completely with the conclusions derived from the supposition.

Finally we reproduce here a pattern of *heulandite* from *Teigars-horn on Iceland* obtained with a cleavage-lamella parallel to (010), parallel to which form this mineral, — whose composition is: $\text{CaAl}_2\text{H}_4(\text{SiO}_3)_6 + 3\text{H}_2\text{O}$, and whose parameters are: $a : b : c = 0,4035 : 1 : 0,4788$, $\beta = 63^{\circ}40'$, is very perfectly cleavable. In the photo (fig. 8 on Plate II) the presence of a binary axis, perpendicular to the photographic plate, is clearly discernible.

§ 5. In this connection a case of *dimorphy* may find its place at the same time, namely that between *amphibole* and *augite (pyroxene)*. As is well known, according to the older conception of TSCHERMAK and others, the rhombic, monoclinic, and triclinic pyroxenes, and the corresponding rhombic, monoclinic and triclinic amphiboles, would be in the relation of *polymerides*, notwithstanding their equal empirical chemical composition: to the *amphiboles* according to these

views, a molecular formula of *four* times the single one, to the *pyroxenes* such of *twice* the single chemical formula of the resp. metasilicates would have to be attributed. Furthermore the crystal-forms themselves of this dimorphous series are related to each other in a close and well known way. The composition of *amphibole* and *augite* can be expressed as that of mixed crystals of $\text{Ca}(\text{Mg,Fe})(\text{SiO}_3)_2$ and $\text{MgAl}_2\text{SiO}_6$; their parameters are:

Of *amphibole*: $a : b : c = 0,5318 : 8 : 0,2936$; $\beta = 75^\circ 2'$.

Of *augite*: $a : b : c = 1,058 : 1 : 0,594$; $\beta = 89^\circ 38'$.

If now for *augite* a somewhat different choice of the axes¹⁾ than the ones here adopted is made, its parameters become: $a : b : c = 1,0921 : 1 : 0,5893$; $\beta = 74^\circ 10'$. In this form the analogy with *amphibole* immediately comes to the fore: the values for *a* and *c* in the case of *augite* are evidently *twice* those of *amphibole*, while the angle of inclination β is about the same. It may be remarked furthermore, that if the conclusions of BRAGG, according to whose investigations the conception of "molecular weight" for the solid crystal is losing its significance, were right, appreciable differences in the structures of the RÖNTGEN-patterns of *amphibole* and *augite* could hardly be expected any more, if the above mentioned great analogy between the structure of the two minerals is taken into account. Indeed, experiment shows this analogy in the RÖNTGEN-patterns of *augite* and *amphibole* for sections parallel to (100) in a striking manner; moreover it is quite well discernible for sections parallel to (001). It is more difficult to distinguish in the patterns obtained parallel to (010), which fact partially may be explained by the not completely similar orientation of the two images with respect to each other, and the accompanying suppression of some spots and unequal distribution of the intensities of the other ones; a direct comparison is here much more difficult than in cases, where the images possess one or more planes of symmetry.

The plates of *amphibole* had a thickness of respectively 1,08, 1,11, and 0,84 mm.; those of *augite*: of 1,02, 1,08, and 1,00 mm. Both minerals came from *Bohemia*; the photos are reproduced in fig. 15 and 16 of Plate IV, and in fig. 17 to 20 on Plate V; the stereographical projections in fig. 18 to 23 on Plate VI.

In every case also these patterns show a symmetry quite in concordance with the conclusions drawn from the proposed theory of the diffraction-phenomenon.

1) In the first choice of parameters, the pyramid *o* had the symbol {122}. We simply take $o = \{111\}$, which symbols are also given by NAUMANN-ZIRKEL, according to the measurements of VON KOKSCHAROW.

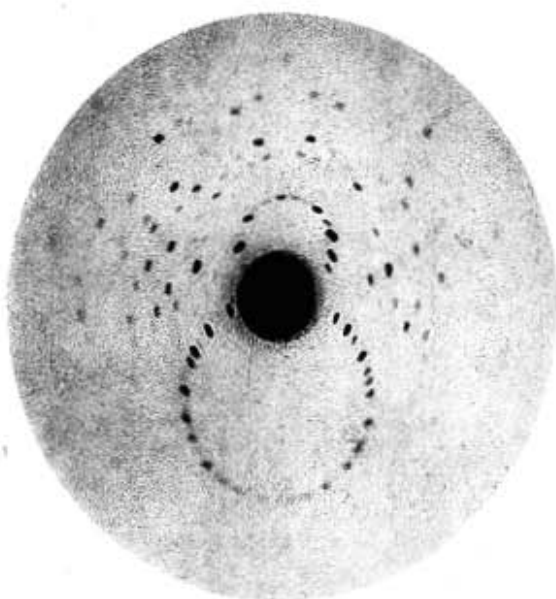


Fig. 1.
Cane-sugar. Plate parallel to (100).

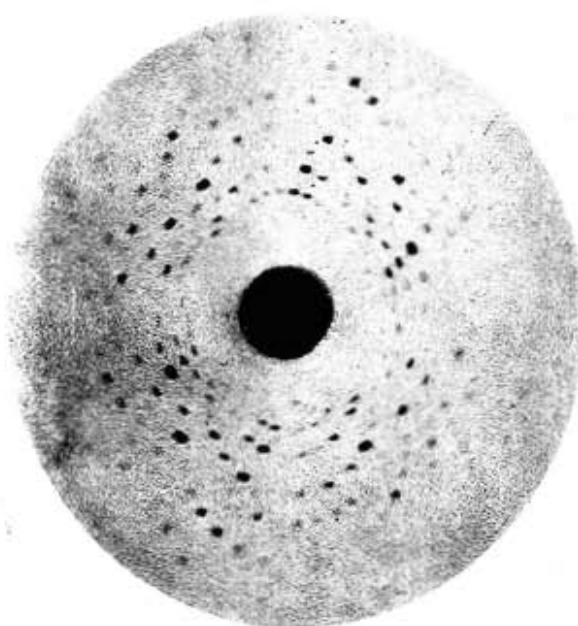


Fig. 2.
Cane-sugar. Plate parallel to (010).

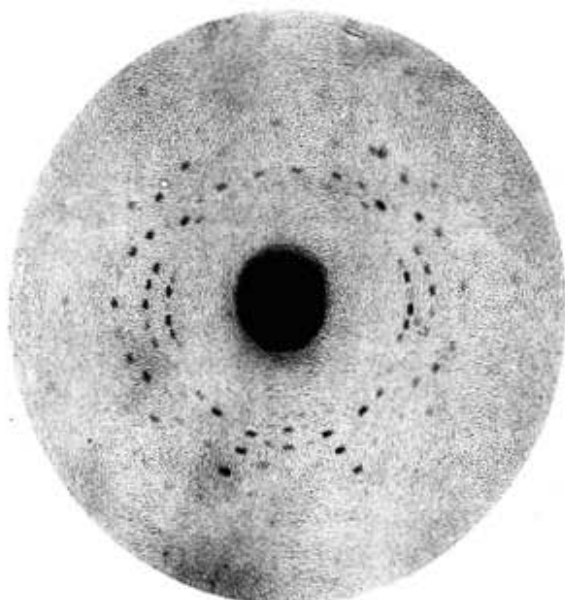


Fig. 3.
Cane-sugar. Plate parallel to (001).

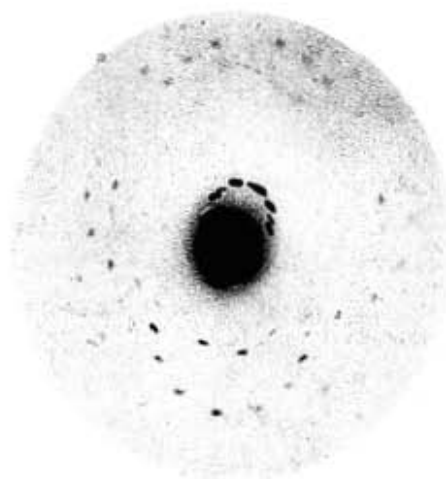


Fig. 4.
Rhamnose. Plate parallel to (100).

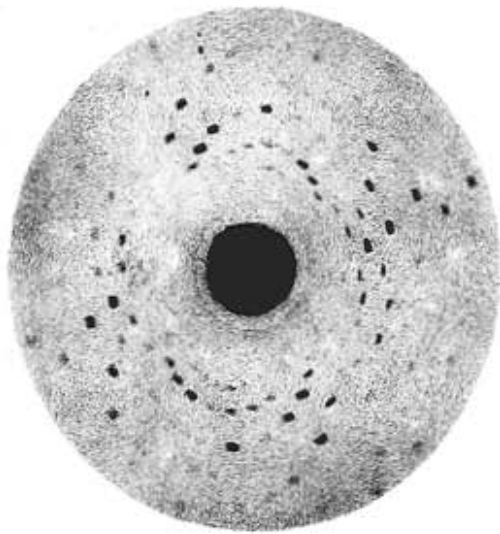


Fig. 5.
Rhamnose. Plate parallel to (010).

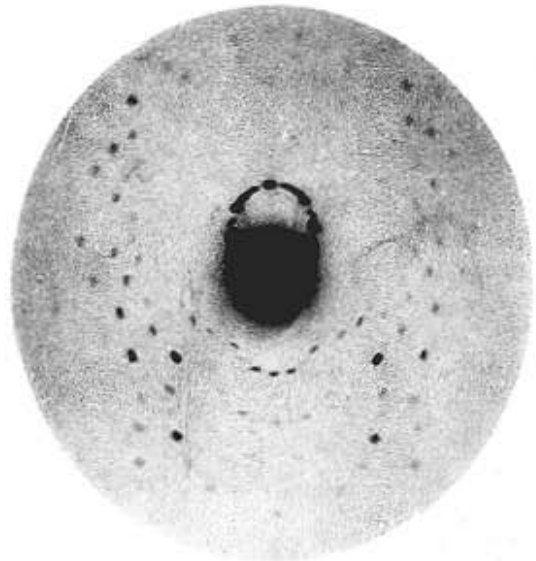


Fig. 6.
Rhamnose. Plate parallel to (001).

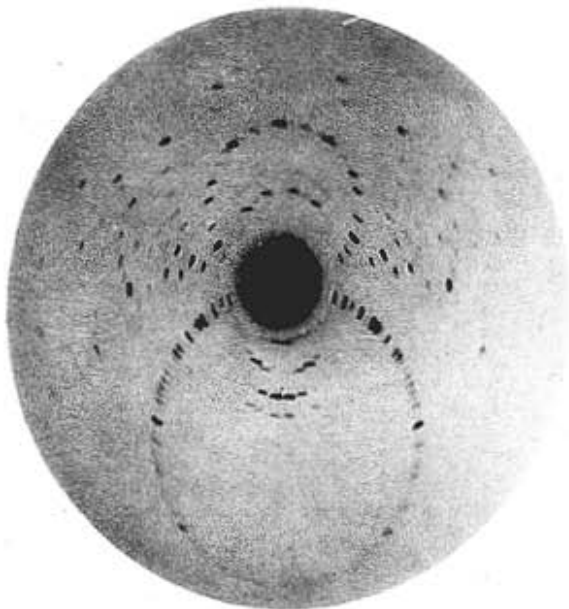


Fig. 7.
Scolesite. Plate parallel to (001).

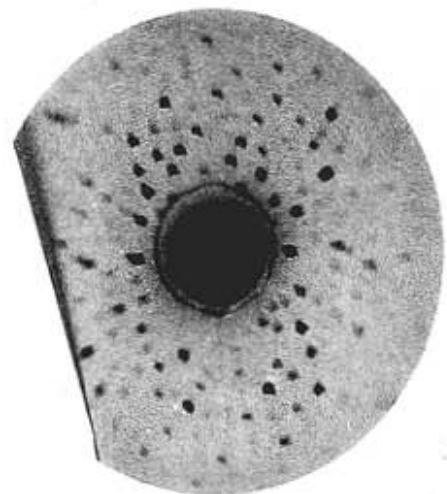


Fig. 8.
Heulandite. Plate parallel to (010).

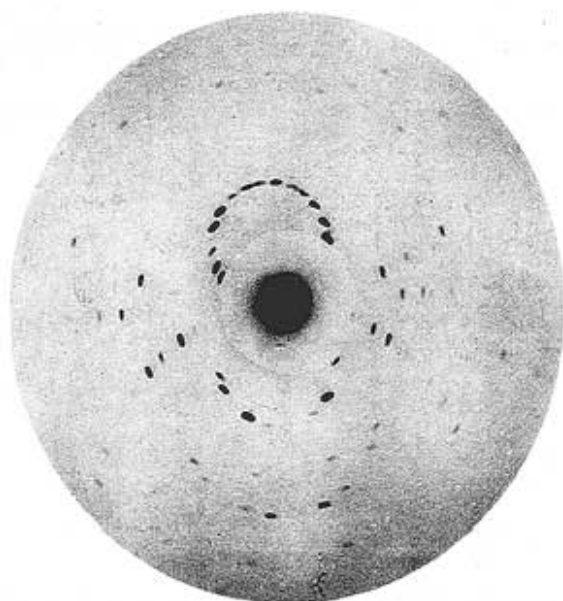


Fig. 9.
Gypsum. Plate parallel to (100).

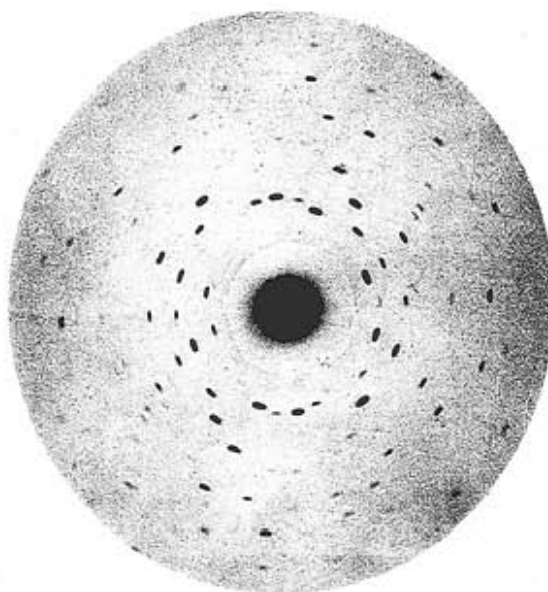


Fig. 10.
Gypsum. Plate parallel to (010).

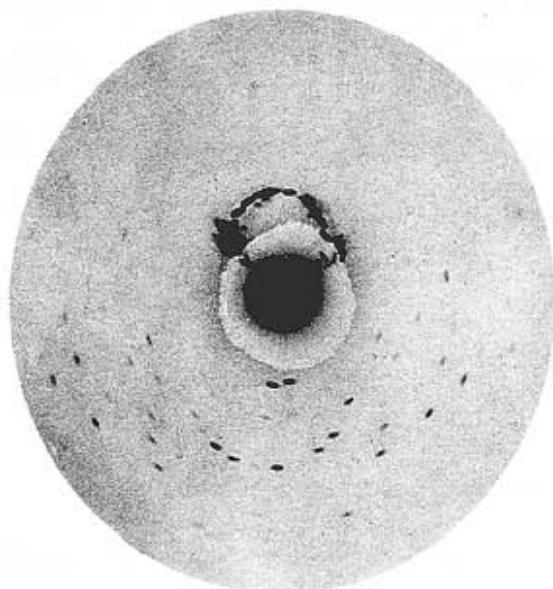


Fig. 11.
Gypsum. Plate parallel to (001).

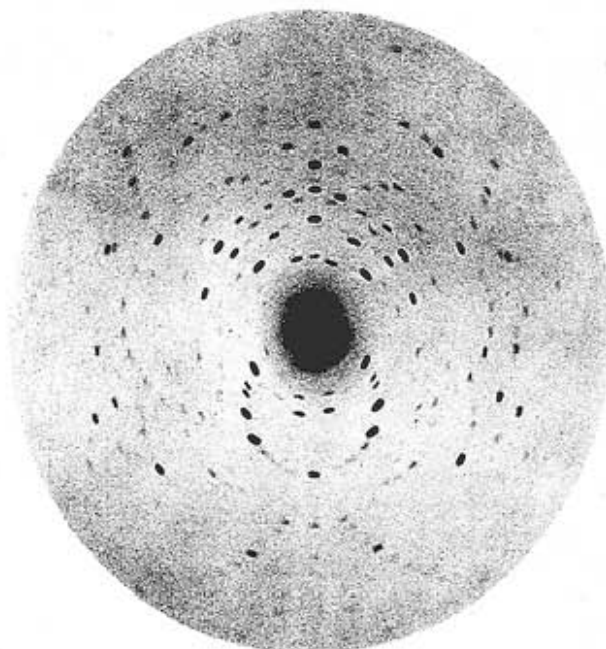


Fig. 12.
Epidote. Plate parallel to (100).

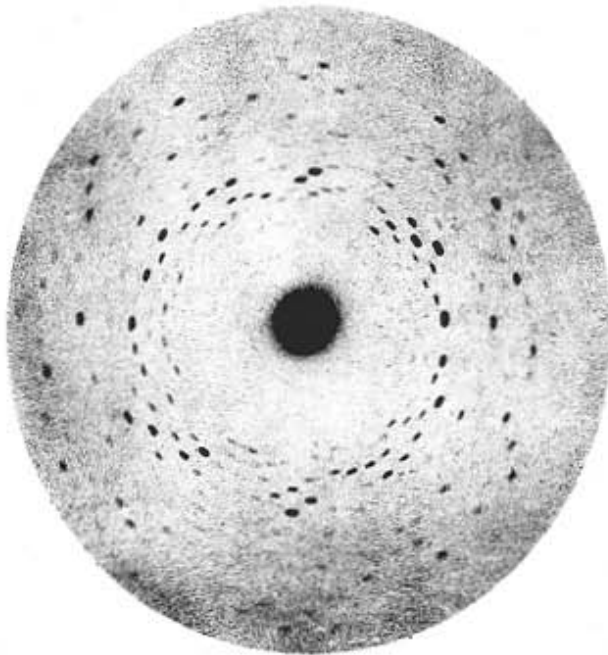


Fig. 13.
Epidote. Plate parallel to (010).

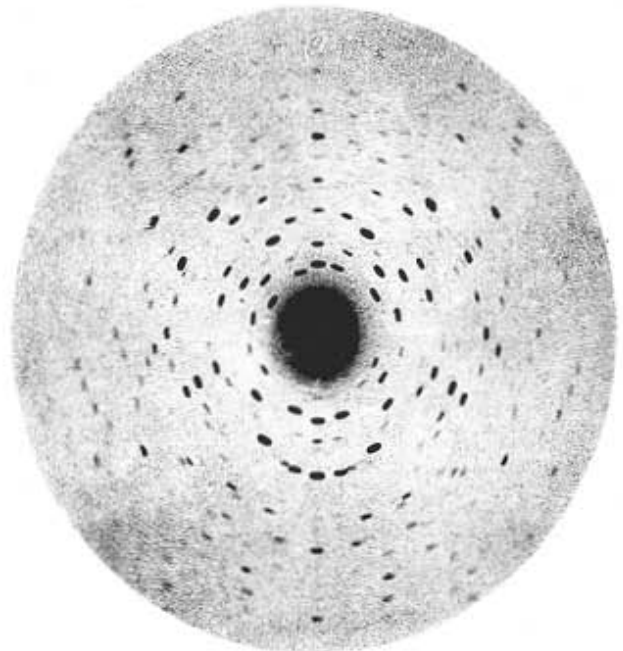


Fig. 14.
Epidote. Plate parallel to (001).

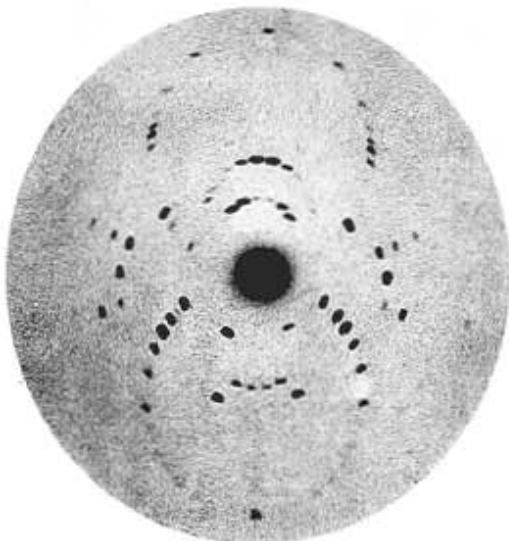


Fig. 15.
Amphibole. Plate parallel to (100).

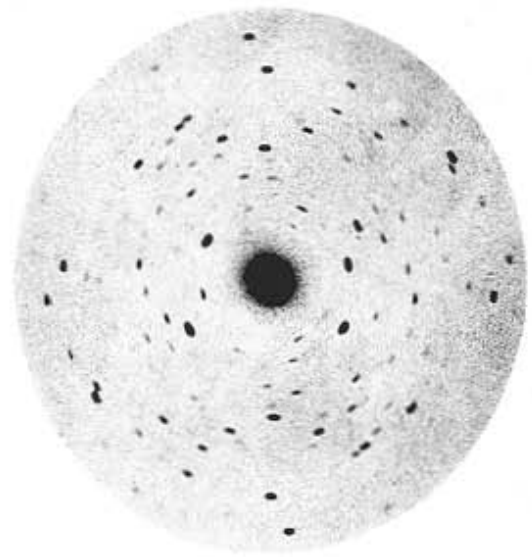


Fig. 16.
Amphibole. Plate parallel to (010).

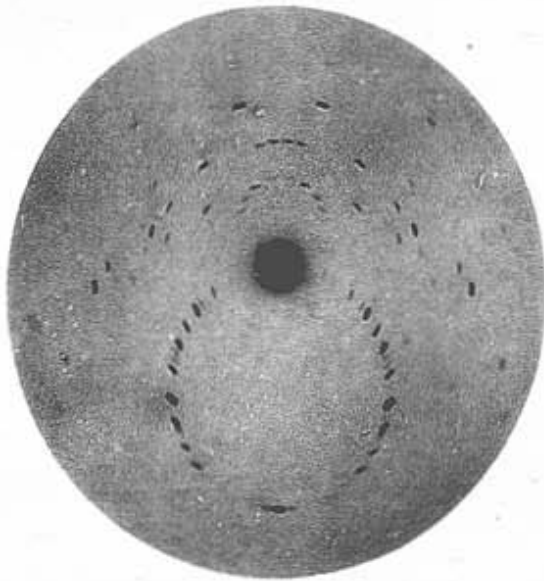


Fig. 17.
Amphibole. Plate parallel to (001).

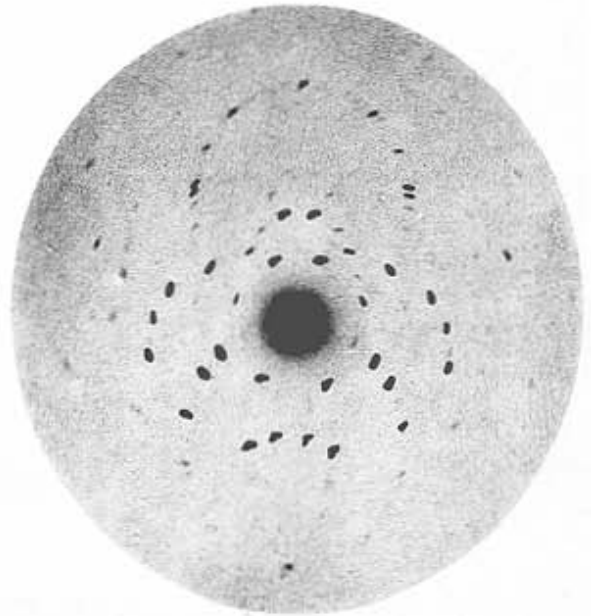


Fig. 18.
Augite. Plate parallel to (100).

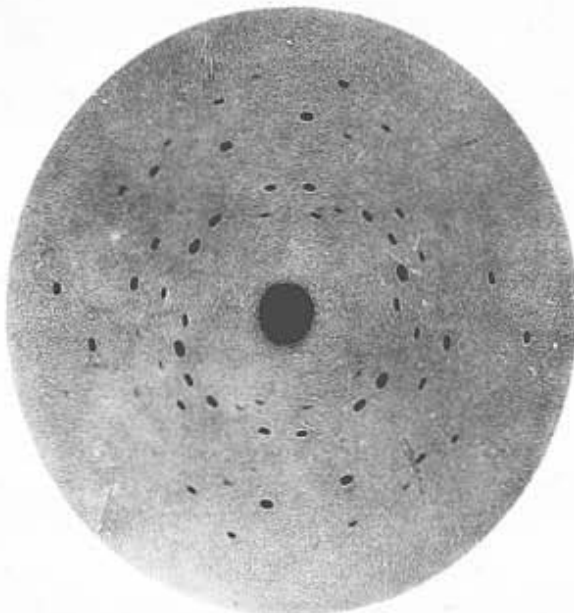


Fig. 19.
Augite. Plate parallel to (010).

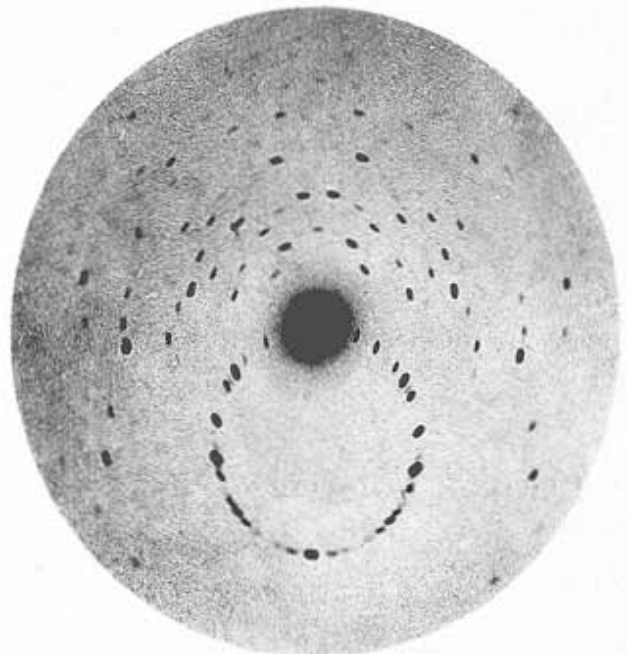
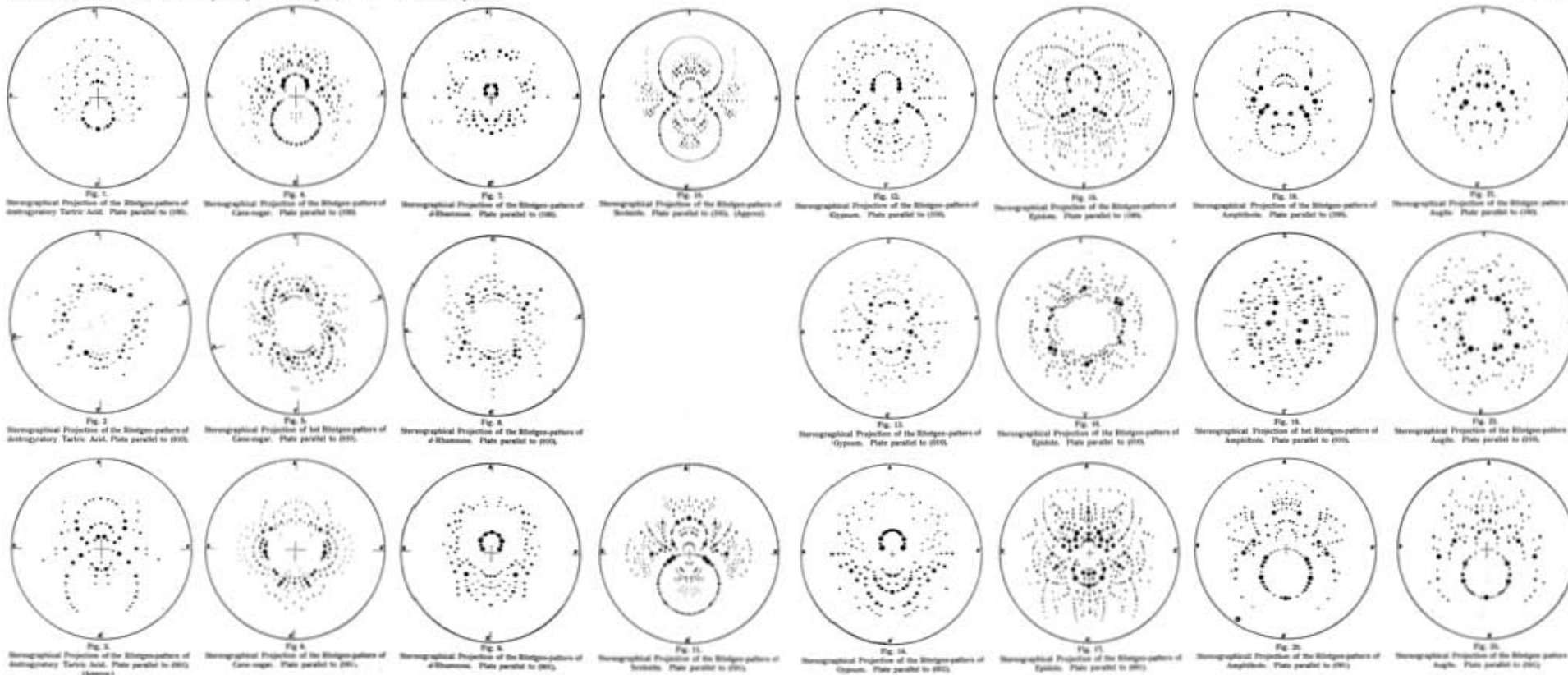
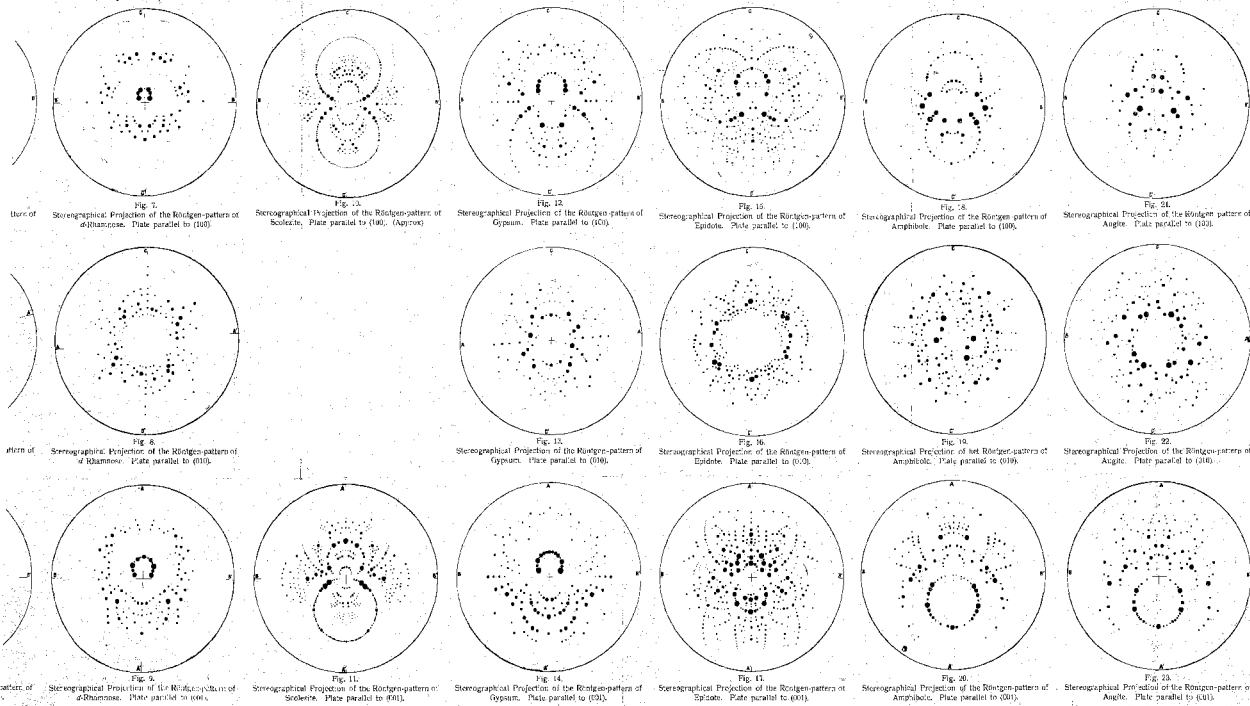


Fig. 20.
Augite. Plate parallel to (001).

H. HAGA and F. M. JAEGER: "The Symmetry of the Röntgen-patterns of Monoclinic Crystals".



Proceedings Royal Acad. Amsterdam, Vol. XXII.



Similar relations as exist between *amphibole* and *augite*, which are found with the minerals *bronzite* and *anthophyllite*, we hope in future to discuss in detail.

In addition we wish to make a remark on some RONTGENOGRAMMES published here, where a bright ring is visible round the black central spot. This occurs in those cases, where by the crystal or by the glass, upon which in some cases the crystal-plates were fixed, secondary RONTGEN-rays are emitted, giving a veil of the photographic image; this veil will be intensified of course by the action of the intensifying screen. Now this screen is perforated in its central part, for reasons formerly explained; thus in this part of the photo the said veil will *not* be intensified by the action of the screen, and a bright ring will appear round the black central spot. From this it follows, that if the crystals must be fixed upon a glass-layer, it will be of advantage to keep this glass-layer as thin as possible, because the secondary radiation of a thinner layer will be less intensive than that of a thicker one.

*Laboratories of Physics and of General and
Physical Chemistry of the University.*

Groningen, January 1916.

Palaeontology. — “*Some young-pliocene Ostracods of Timor*”. By Miss E. C. FVAN. (Communicated by Prof. J. W. MOLL).

(Communicated in the meeting of Jan. 29, 1916).

The Ostracods, which will be discussed in this essay, have been obtained from washings of tertiary clay of the left bank of the Mota Talau near Atamboea in Timor. This clay, which according to the label which went with it, was formed in the latest part of the Pliocene, was collected by Prof. Dr. G. A. F. MOLENGRAEFF and Mr. F. A. H. WECKHERLIN DE MAREZ OYENS m. e. on the expedition which took place during 1910—1912 to the isle of Timor under the auspices of the former. The leader kindly allowed me the use of the material, for which kindness I express my thanks to him here.

The rests of the different Ostracods have been preserved excellently. Very often they are quite transparent, often white, sometimes black and occasionally blue. This last colour is very likely caused by vivianite. By a treatment with hydrochloric acid appeared, that the transparent ones consist also almost quite of carbonate of lime.

This last kind of valves are particularly fit to mark the “Innenrand”, the “Verwachsungslinie” and the “randstandige Porenkanäle” (10, p. 102; 11, p. 2).