Geologiska Föreningen i Stockholm Förhandlingar

Publication details, including instructions for authors
and subscription information:

<http://www.tandfonline.com/loi/sgff19>

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Published online: 04 Jan 2010.

To cite this article: G. Aminoff (1919) X-Ray Asterism on Laue-Photogramms,
Geologiska Föreningen i Stockholm Förhandlingar, 41:7, 534-538, DOI:
[10.1080/11035891909444856](https://doi.org/10.1080/11035891909444856)

To link to this article: <http://dx.doi.org/10.1080/11035891909444856>

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X-ray »asterism» on Laue-photogramms.

By

G. AMINOFF.

In a previous paper¹ the author has published some observations concerning Laue-photogramms of dehydrated brucite as well as of oxidated pyrochroite. These photogramms have two characteristic features: their symmetry is the same as that of the original substance, and instead of spots symmetrically arranged stripes occur. Apparently the stripes, corresponding to the planes {21 $\bar{3}$ 1}, are situated in about the same places where spots occur in the normal photogramms. Consequently it seems probable, that the crystal still possesses a nearly regular arrangement of the atoms² and that the distances in the space-lattice are only slightly changed. There is also for the present no reason to suppose, that the oxygen-atoms have changed their position in relation to the Mg-atoms. A movement along the 3-al axes to $\left[\begin{smallmatrix} 2 & 1 & 0 \\ 3 & 3 & \end{smallmatrix}\right]$ or $\left[\begin{smallmatrix} 2 & 1 & 1 \\ 3 & 3 & 2 \end{smallmatrix}\right]$ is in any case impossible, as hereby hexagonal symmetry is obtained.

By taking away one oxygen- and two hydrogen-atoms from the brucite-structure the following structure is obtained:

$$\text{Space-lattice } \Gamma_h \begin{cases} \text{Mg} : \left[\begin{smallmatrix} 0 & 0 & 0 \\ 3 & 3 & 3 \end{smallmatrix}\right] \\ \text{O} : \left[\begin{smallmatrix} 2 & 1 & 2 \\ 3 & 3 & 9 \end{smallmatrix}\right] \end{cases}$$

¹ Geol. Fören. Förh. 41 (1919), p. 428.

² RINNE already in the year 1891 found, by means of optical methods, that dehydrated brucite is still homogeneous and optical uniaxial. Zeitschr. d. deutsch. geol. Gesellsch. 1891, p. 231.

This structure, however, is no longer ditrigonal-scalenohedric, but ditrigonal-pyramidal (C_{3v}). It possesses the 3-al symmetry-axes and the symmetry-planes of the $Mg(OH)_2$ -structure, but has no symmetry-centre. On account of the centro-symmetrical character of the Laue-effect this structure, however, gives photogramms with the same symmetry as the brucite. The structure is represented by the SCHÖNFLIES space-group C_{3v}^1 .

Four space-groups with hexagonal lattice (I_h) are isomorphous with the symmetry-class C_{3v} , viz. $C_{3v}^1 \dots^4$. C_{3v}^3 and C_{3v}^4 , however, possess only gliding-reflexion-planes and in C_{3v}^2 there are 3-al rotation-axes, not lying in the symmetry-planes,¹ which is not the case with the MgO -structure.

If convenient material could be obtained, there would be a possibility to prove the hemimorphism of the structure by means of the KUNTZ' method. Some tests, made by the author, however, gave no definite result. The employed material, however, was very little suitable for this purpose.

By the oxidation of $Mn(OH)_2$ to a substance, approaching to $MnO \cdot OH$, the valency of the Mn-atom is altered from two to three. From each unit parallelepipedon one H-atom is taken away. The result is, as was the case with MgO , the ditrigonal-pyramidal space-group C_{3v}^1 . Both the oxygen atoms are still situated in their places, but only one of them is connected with a hydrogen atom. The Laue-photogramms must show the same symmetry as those of the normal pyrochroite.

It is evident, that if the structure after the chemical change is *exactly* regular, it would give a normal photogramm. We must therefore propose some change in the position of the atoms in order to explain the 'asterism'-phenomenon.

The asterism-effect was already observed by HUPKA² when

¹ Cfr. NIGGLI, *Geom. Kryst. des Diskontinuums*, p. 232 or HILTON, *Math. Crystallography*, p. 220.

² *Phys. Zeitschr.* 14 (1913), p. 623.

photographing metal folios, as well as by F. M. JAEGER¹ in connection with his X-ray investigations of the minerals manginite and goethite. JAEGER supposes the effect to be connected with 'intergrowths and twinning of fibre-shaped individuals in these crystals'. RINNE,² who publishes some excellent photogramms, showing the asterism, says: »Die Erscheinung ist also auf eine Deformation des Baues zurückzuführen, dessen Strukturflächen das Röntgenlicht nicht mehr in gesonderten Strahlen, sondern zufolge Knickung und Verrundung in Büschelform reflektieren, gerade so wie es bei vielen Lichtfiguren geschieht.»

The cited arguments, however, do not seem to be quite able to explain the remarkably *regular* character of the effect. The occurrence of the phenomenon in pseudomorphoses also affords some words about this question. Perhaps the following reflections may contribute to the understanding of the phenomenon.

The incident beam of X-rays is »reflected» against a reticular-plane and produces a spot on the plate. If two or several planes intersect under very small angles the corresponding spots are near each other on the plate. It is a well known fact, that if these planes lie in a zone, the reflected rays all are generators to a circular cone, whose axis is the zone-axis. If an ordinary reticular-plane is altered into a series of tautozonal planes, intersecting under small angles, the single spot is changed into a stripe, consisting of a series of spots. This stripe follows the curve, which the cone produces on the plate.

Suppose parallel atom-planes are translated distances, not being entire multiples of the atom-spacings, all other atom-planes in the structure are altered into series of tautozonal planes.³ The zone-axis is the intersecting-line between the translation-plane and the atom-plane.

¹ Koninkl. Akad. Wetenschapp. Amsterdam. Proceed. Vol. XVIII, No 9, p. 3.

² Sitz.-berichte. Sächs. Akad. Wissensch. Math. nat. naturw. Kl. Leipzig. LXVII, p. 223.

³ i. e. »folded» or bent around an axis (or better set of parallel axes), which is the intersection-line between the translation-plane and the atom-plane.

It seems difficult to imagine any other deformation, giving the desired result. An irregular (or spherical) curved atom-plane ought to give an irregularly (or circular) distorted spot. (Cfr. what is said about martite later on.)

The geometrical construction of the curves, into which the spots are changed, offers no difficulties. Two special cases ought to be noted: 1. The translation-plane lies in a certain zone. All spots, lying in this zone are altered into stripes, following the cone-section of the zone. 2. The translation-plane is parallel to the plate. All spots on the plate are altered into stripes, converging against the centre of the plate. The atom-planes at right angle to the plate produce stripes, diverging from the centre of the plate.

The above proposed deformation of the structure is consequently able to explain the most characteristic features of the asterism-phenomenon, viz. that the spots are changed into regular running stripes, and that (by brucite and pyrochroite) atom-planes, at right angle to the photogr. plate, produce stripes, diverging from the centre of the plate. The control, however, whether the stripes follow the curves, constructed as above, offers difficulties as the position of the supposed translation-plane is not always known.

It is probable that, even if the presumed deformation of the structure is only approximately realised, yet mainly the same effect is obtained on the plate. There would in that case be some possibility for small, quite irregular displacements of the atoms.

Now the question is, whether this kind of translation is crystallographically probable. It ought then to be noted that just by bending plastic crystals such a translation must be assumed. (Cfr. MÜGGE¹.) It is characteristic that specially those crystals, which easily allow permanent deformations, show the most pronounced X-ray asterism, as for instance

¹ Neues Jahrbuch für Mineralogie etc. 1898, I, p. 156.

brucite, kœnenite and alkali-haloids. By first bending and then flattening such crystals RINNE (l. c) has obtained photogramms, showing the most beautiful asterism. On the other hand, by pressing e. g. brucite $\perp$ (0001), the effect is, that the free sides (prism-faces) of the crystal are curved, which may be explained so that the atom-planes (0001) glide over each other for distances, which of course do not need to be entire multiples of the atom-distances in (0001). By pressing crystals of e. g. KCl real translations // (110) may also take place, which, however, have no influence upon the asterism-effect.

In pseudomorphoses showing asterism one consequently also must anticipate deformations, where parallel atom-planes have glided over each other. It is characteristic that by the presence of real translation-planes and plasticity, as by brucite and pyrochroite, the asterism is much more pronounced than by pseudomorphoses, where no distinct translations exist as by martite. The Laue-photogramms of the latter show only partially regular stripes. Many spots are irregularly distorted. The remaining atoms must consequently have moved small distances in several directions and the atom-planes are not »folded» around only one axis (or to put it more exactly, around a set of parallel axes).

At last the author wishes to remark, that the fact, stated by VEGARD,¹ that by dehydration of chabasite-crystals the maxima of reflection do not change their positions, but only are weakened, agrees very well with the authors opinion that in the structure of the dehydrated hydrates the positions of the remaining atoms are only slightly changed.

Stockholms Högskola. Mineralogical institute. Dec. 1919.

¹ Ann. der Physik 54 (1917), p. 162.