# NOTISER

A METHOD OF COUNTING OUT PETROFABRIC DIAGRAMS

The counting out petrofabric diagrams as described in the literature is carried out by means of a celluloid counter with circular holes representing 1, 1,5 or 2 per cent of the area of the circle of projection. The present writer has found it more convenient to construct a net of circles with the percentage wanted, with the distance between the centres equal to the radius of the circles. The diagram, with the projection points plotted on a tracing paper, is placed upon this net, and is covered by a second sheet of tracing paper. The numbers of points falling within each of the circles of the net can then easily be counted and are marked by corresponding figures on the upper paper. In this way the counting out of a diagram will be easier as well as more impersonal than by using a celluloid counter.

Petrofabric diagrams are plotted in an equal area projection (the Lambert projection of cartography) by use of the so called Schmidt net, and are counted out by circles as described above. This method has been criticized by Mellis[1] on the ground that the concentration in a given point of the hemisphere correctly should be measured by the number of plots falling within a spherical circle with its centre in the point. The plane circles generally used represent spherical circles only in the centre of the projection, in the peripheral parts they represent (somewhat deformed)

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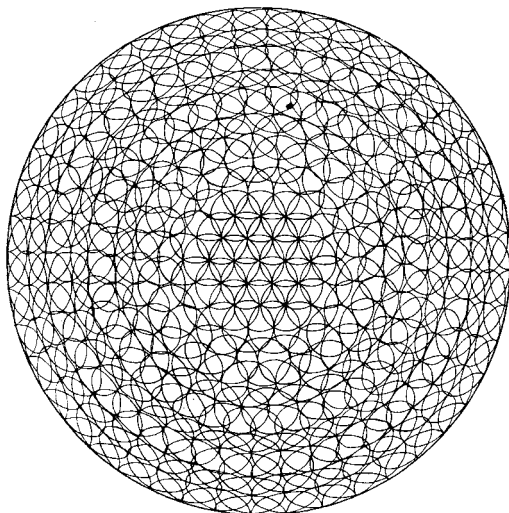
[1] Otto Mellis: Gefügediagramme in stereographischer Projektion. Min.-petr. Mitt, 53, p. 330, 1942.

ellipses on the hemisphere with the longer axes in a meridional direction. Due to this circumstance some distortion of the diagram will take place. To avoid this, Mellis proposes to represent petrofabric diagrams in the stereographic projection, in which a circle on the sphere is represented by circles in the plane projection. In the stereographic projection a diagram can correctly be counted out by circles, the radii of which, with a given percentage, increase with the distance from the centre of the projection.

There are two chief objections to the use of the stereographic projection for petrofabric diagrams. Firstly, the equal area projection has already been used for a great number of published diagrams, and secondly the stereographic projection has the disadvantage of representing equal angular distances on the sphere by greatly varying linear distances in the projection. The paper of Mellis has therefore occasioned the author to construct the net here reproduced for the counting out of petrofabric diagrams in the equal area projection, by the use of spherical circles with radius 8°,1, representing 1 per cent of the hemisphere.[1] As is seen from the figure the sphercial circles are represented by (somewhat deformed) ellipses, the difference between the axes of which increases with the distance from the centre of the projection. Within a distance of 25° from the centre the difference between the axes is less than one milimetre on a net with a radius of 10 cm, and here circles may be used without any appreciable error. Similar nets might be constructed with 1,5 per cent circles, and with 2 per cent circles, with radii of 10°,0 and 11°,5, respectively, and with circles with a radius of 5° for the constructive counting out of diagrams proposed by Mellis (*l. c.*).

By devoting some time and care every one may construct similar nets for his own use, to get fine results, however, exactness in construction as well as skill in drawing is needed. If the method here suggested should meet with general approval, it would be desirable that some firm or institution undertake the construction of the nets, which might then be reproduced and distributed for sale. The present writer is well aware, that the orientation of minerals in rocks is not a finely adjusted process so that the errors resulting from the commonly used methods are far from being serious. Yet, the use of correct methods will give satisfaction to the workers in this field, and uniformity in methods will be of importance to this branch of science as a whole.

Trygve Strand.

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[1] The area of a spherical calotte (a spherical circle with radius φ) is given by $2\pi R^2 (1 - \cos \varphi)$, where R is the radius of the sphere. $1 - \cos \varphi$ is thus the area of the spherical circle in proportion to the area of the hemisphere.

UNIT CELL AND SPACE GROUP OF CHALCOCITE, Cu_2S

In 1930, when doing X-ray work in the Mineralogical Laboratory in Cambridge, I took a number of oscillation photographs of chalcocite from Cornwall. Axes of rotation were the 3 crystallographic axes. From the photographs the following dimensions of the unit cell were derived:

$$a_o = 11.8 \text{ Å} \qquad b_o = 27.0 \text{ Å} \qquad c_o = 13.4 \text{ Å}.$$

These values are not very exact; they may be uncertain by about 0.1 Å. They are in close agreement with a set of values which has been published in the meantime.[1] Because of the very large number of atoms which must be contained in this cell I did not think it possible to determine the structure from the photographs; in any case such a determination would be an extremely laborious task; and so I did not publish any account on my work chalcocite. Reviewing my old photographs I find that a fairly reliable determination of the space group is possible. The interpretation of the photographs was done by the graphical method worked out by J. D. Bernal.[2] Because of the large size of the unit cell a unique interpretation was possible only for part of the spots in each photograph. Even so I obtained a list of about 200 different sets of indices which may be regarded as well established, many of them being represented by several spots. In all of these observed sets of indices hkl the sum $k+l$ is even, that is: k and l are either both even or both odd; in other words: hkl is halved if $k+l$ is odd. This seems to be the only kind of abnormal spacings. The only space group in accordance herewith is C_{2v}^{14} — Amm. Interchanging the axes a and c also C_{2v}^{11} — Cmm. Q^6 — $C222$ and Q_h^{19} — $Cmmm$ are possible. As no faces indicating a lower symmetry than the orthorhombic holohedral have been observed on crystals of chalcocite, all these space groups but the last one are improbable. *The space group of chalcocite is therefore probably Q_h^{19} — $Cmmm$.* To be in accordance with the space group notation here adopted we have, as mentioned, to interchange the axes a and c in the usual orientation of the chalcocite crystals.

As to the number of atoms in the unit cell neither the cell dimensions nor the specific gravity of chalcocite are known with sufficient accuracy to give a unique result. Using the above cell dimensions and the specific gravity 5.8 we obtain about 93 Cu_2S in the unit cell. It is, however, highly probable that the correct number is *96*. This is supported by several facts. 96 Cu_2S in the unit cell gives a calculated density of 5.97, which is the value found for cubic Cu_2S by Tom. Barth.[3] In other words: the cubic cell, which contains 4 Cu_2S, is very exactly 1/24 the volume of the orthorhombic cell. It might be assumed that the orthorhombic cell would be built up of 24 more or less distorted cubic cells, but this does not seem to be the case. It is true that the intensities of

1   P. Rahlfs, Z. physik. Chem. (B) *31*, 157, 1936.
2   J. D. Bernal, On the interpretation of X-ray, single crystal, rotation photographs. Proc. Roy Soc. (A) *113*, 117, 1927.
3   Tom. Barth, Die reguläre Kristallart von Kupferglanz. Centralblatt f° Min. etc., A, 1926, p. 285.

the spots in the oscillation photographs indicate a fairly distinct pseudo cell which is $1/24$ the volume of the orthorhombic unit cell, but its shape is very far from cubic. This pseudo cell is indicated by the relatively very high intensities of spots with indices like 084, 086, 344, 346, 3 12 0, 3 12 2, 3 12 4. These indices are of the form $3n$, $4n$, $2n$, and the pseudo cell thus has the dimensions $\frac{1}{3}a_o$, $\frac{1}{4}b_o$, $\frac{1}{2}c_o$, or 3.94 Å, 6.75 Å, 6.70 Å. The pseudo cell is therefore pseudo-tetragonal, and also pseudo-hexagonal. (In accordance with what has been said above the product $3.94 \text{ Å} \times 6.75 \text{ Å} \times 6.70 \text{ Å}$ is very nearly equal to $(5.59 \text{ Å})^3$, which is the volume of the unit cell of cubic Cu_2S.) — The general positions of equivalent points in the space group Q_h^{19} — $Cmmm$ are sixteen-fold. This is an additional indication that the real number of "molecules" Cu_2S in the unit cell is 96 and not a number in the neighbourhood of 96, for 192 and 96 positions are readily built up of sets of 16. $12 + 6$ sets of 16 will be needed, and the number of parameters to be fixed to determine the structure is probably $(12 + 6) \times 3$, or 54.

Oslo, Mineralogisk-geologisk museum, November 1944.

<div align="right">Ivar Oftedal. .</div>

NOTE ON THE METAMORPHIC DIFFERENTIATION
OF SOLID ROCKS

This note should be considered as a supplement to my article in this journal *24* p. 98—111.

The activity of the given mineral usually varies with the kind and composition of the surrounding minerals (the variation of the activity with Z) even if the composition and the size of the given mineral and the P, T are constant. This is because of the influence of the surrounding phases on the surface tension of the considered phase. Thus, in a homogeneous rock consisting of chemically compatible minerals it may happen that the activities of the assemblage decrease if special minerals cluster concretionary together. During the metamorphism there will therefore exist activity gradients in a homogeneous rock that try to differentiate the rock by dispersion of some minerals at some places, migration of the dispersed elements towards places of lower activities and consolidation there. The variation of the activity of a mineral with the surrounding phases is thus — along with the variation of the activity with the pressure, P, and the size of mineral, Y — the most important factor to consider when treating the metamorphic differentiation theoretically. In this way I explain the occurrence of concretions of many mineral assemblages as for instance calcite in slate, chert in chalk, quartz and small pegmatite veins in gneisses, epidote, quartz and calcite in low grade amphibolites and so on. During the growth of the concretion which commonly consists of minerals containing the element with the greatest power of diffusion in the rock, the other minerals must be enriched in a zone along the boundary of the concretion.

Mineralogisk Institutt, Oslo, February 1935.

<div align="right">Hans Ramberg.</div>