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The twin formation of tugtupite, a contribution[1]

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SUMMARY. Tugtupite, space group $I\bar{4}$, belongs morphologically to the crystal class $\bar{4}2m$. The paper describes pseudotrigonal contact triplets recently found as freely developed individuals on two specimens donated to the Geological Museum, Copenhagen. The contact triplets, described as a symmetric twin, have the composition planes, which are also the twin planes, $(10\bar{1})$ and $(01\bar{1})$; the pseudo-threefold axis, along which the crystals are pronouncedly elongate, is [111]. The calculated re-entrant angles on the two sides of the pseudotrigonal prism, the protruding angle on the third side, and the 'central misfit', expressed as the geometrical angles, are 178° 41′, 181° 20′, and 2° 39′ respectively. Tetragonal crystals forming pseudotrigonal twins are rare and it is emphasized that the pseudotrigonal habit has become apparent only because: the faces developed on individual I and on individuals II and III are not the same; and the proportion between the lengths of the traces of the faces $(\bar{1}01)$ individual I and $(0\bar{1}1)$ individuals II and III in a plane perpendicular to the pseudo-threefold axis and the traces in the same plane of all other faces constituting the pseudo-threefold prism are 2:1.

TUGTUPITE ($Na_8Al_2Be_2Si_8O_{24}(Cl,S)_2$), discovered in 1957 by Professor H. Sørensen at Tugtup agtakôrfia on the north coast of the Tunugdliarfik Fjord, South Greenland, was described in the reports of the International Geological Congress, Norden (Sørensen, 1960), under the provisional name 'beryllium sodalite'. Additional data were published by Sørensen (1963) and it was suggested that the mineral should be named tugtupite, the name being derived from the locality where the mineral was first found. In 1965 the I.M.A. Commission on New Minerals and Mineral Names approved the name, and in 1966 M. Danø described the crystal structure and demonstrated that crystals of tugtupite are tetragonal, but pseudocubic, with the space group $I\bar{4}$; the unit cell parameters of tugtupite from the Kvanefjeld plateau are: $a = 8{\cdot}637$ and $b = 8{\cdot}870$ (Danø, 1966).

The present author, in Sørensen *et al.* (1971), described the crystal habit. Tugtupite, in spite of a pronounced holosymmetrical appearance, belongs morphologically to the crystal class $\bar{4}2m$. Tugtupite is optically positive and uniaxial or has a small axial angle (up to about 10°). The present author also described the pseudocubic penetration twins often seen in thin sections of tugtupite.

The present paper describes in detail pseudotrigonal contact triplets of tugtupite found recently on two specimens brought to the Geological Museum, Copenhagen, by a private collector.

Present investigation. At the end of 1974, a private collector, G. Chris-Olsen, presented the author with two specimens from the tugtupite-bearing albitite at the Kvanefjeld plateau, Ilimaussaq, South Greenland, known to contain the desired intense carmine-red tugtupite used as a semi-precious stone.

The two samples consist mainly of unusual, coarse-grained aggregates of lath-shaped albite crystals, aggregates of acicular aegirine crystals, and smaller irregular patches of tugtupite. Both samples contain numerous small cavities lined by white albite crystals and one major cavity likewise lined by albite crystals, up to 1 cm. These major cavities, one on each sample, contain plenty of massive tugtupite.

Under high magnification (×100) it can be seen that some of the plane surfaces of the tugtupite patches are built up of numerous, small, colourless to pinkish, crystals of tugtupite, partly in parallel orientation. These crystals all present the tetragonal, prismatic habit previously described, Sørensen *et al.* (1971). On some of these surfaces, numerous apparently simple trigonal (prism and pyramid), colourless, partly transparent crystals can be observed, see fig. 1. A Guinier-Hägg powder diagram uniquely identified these trigonal-looking crystals as tugtupite. The crystals are arranged in groups, and inside each group the crystals are in parallel orientation. There is no observable relation between the crystallographical orientation of the tetragonal crystals forming the surfaces on which the apparent trigonal crystals are sitting and the apparently trigonal crystals.

Both the albite crystals and the tugtupite crystals are dusted with very small aggregates, consisting of

[1] Contribution to the Mineralogy of Ilímaussaq, No. 43.

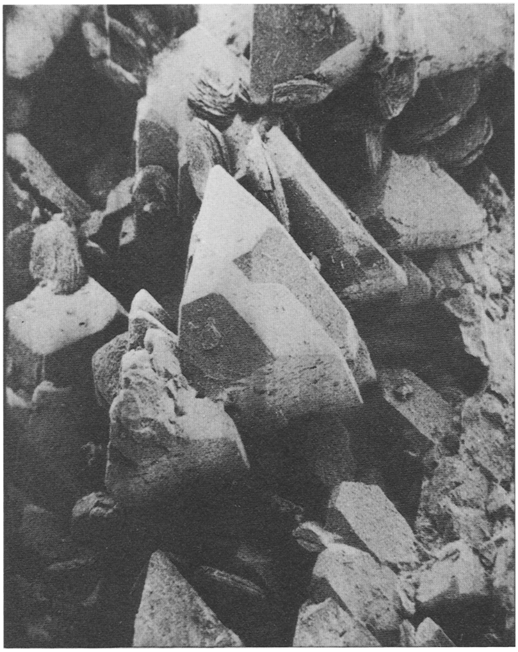

FIG. 1. Scanning electron micrograph ($\times 70$) showing a pseudotrigonal contact triplet.

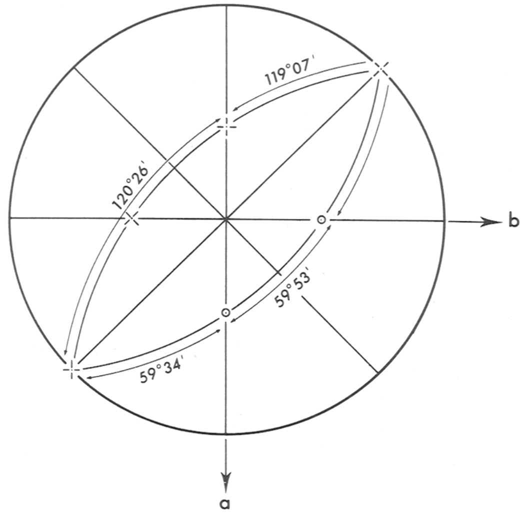

FIG. 2. Stereographic projection of the zone [111] of tugtupite with the angles calculated by means of the unit cell parameters. ⋰⋱ represents faces, belonging to the forms developed and within the zone, not developed on individual I.

4-6 hexagonal platy, light-brown crystals of an apparently new mineral belonging to the zeolite group, which will be described in a separate paper.

Optical properties. Examinations of thin sections, orientated perpendicular to the apparently trigonal main axis of the crystals, immediately showed the presence of remarkable contact triplets.

The contact planes, which are also the twin planes, were determined by means of the universal stage to be $(10\bar{1})$ and $(01\bar{1})$ for the twin formation individual I-II and I-III respectively. The faces bounding the single individuals, also determined on the universal stage, are:

Individual I: $(10\bar{1})$, $(01\bar{1})$, $(\bar{1}01)$, and $(1\bar{1}0)$
Individual II: $(\underline{10\bar{1}})$, $(\underline{0\bar{1}1})$, $(\underline{\bar{1}10})$, and $(\underline{01\bar{1}})$
Individual III: $(\underline{01\bar{1}})$, $(\underline{10\bar{1}})$, $(\underline{0\bar{1}1})$, and $(\underline{\bar{1}10})$.

The axis of elongation, the pseudo-threefold axis is [111].

Attempts to measure the 'prism' of the triplet on the two-circle goniometer failed due to the physical state of the faces. However, it was possible to determine on the two-circle goniometer the position of the three faces on the top of the triplet relative to the pseudoprism. On a stereogram the indices of these three faces were thereafter easily determined as:

Individual I: (101)
Individual II: $(\underline{011})$
Individual III: $(\underline{011})$.

Fig. 2 shows a stereographic projection of the zone [111] of tugtupite. The angles given have been calculated by means of the unit cell given below. The pseudohexagonal symmetry is, although expected, remarkable. More remarkable, however, is that, of the forms developed, {110} and {101}, the first form with two faces, $(1\bar{1}0)$ and $(\bar{1}10)$, the second form with four faces, $(10\bar{1})$, $(\bar{1}01)$, $(01\bar{1})$, and $(0\bar{1}1)$, in the zone, two of the faces, one from each form, $(\bar{1}10)$ and $(0\bar{1}1)$, are not developed. In the stereogram these faces are marked by a diagonal cross (⋰⋱).

It should be emphasized that the stereogram, fig. 2, and the above remarks refer to individual I in fig. 3. For individuals II and III the faces missing of the forms {110} and {101}, with the same faces as above in the zone, are $(1\bar{1}0)$ and $(\bar{1}01)$.

By means of the unit cell $a = 8{\cdot}637$, $b = 8{\cdot}870$ the re-entrant angles on the two sides of the pseudotrigonal prism, the protruding angle on the third side and the angle between $(10\bar{1})$ individual III and $(01\bar{1})$ individual II (the central misfit) were calculated as 178° 41', 181° 20', and 2° 39' respectively; the values represent the geometrical, not the crystallographical, angles between the faces, cf. fig. 3.

A stereographic projection of all the faces developed on all three individuals is shown in fig. 4A.

Fig. $4B_1$ and B_2 show a drawing of a section 'cut' perpendicular to [111], of an idealized triplet and a drawing of the top of an idealized triplet respectively, both in orthographic projections.

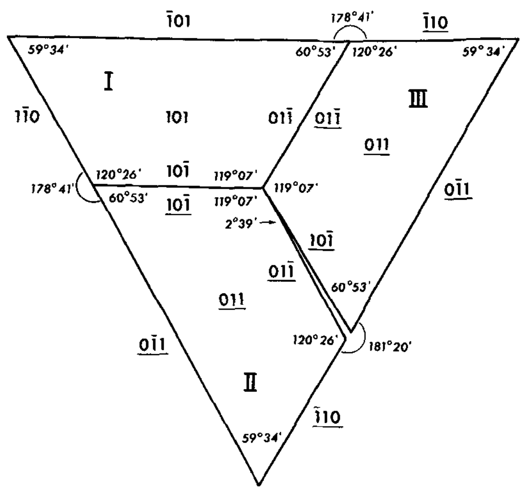

FIG. 3. Orthographic projection || [111] showing the calculated angles between the faces constituting the pseudo-threefold prism.

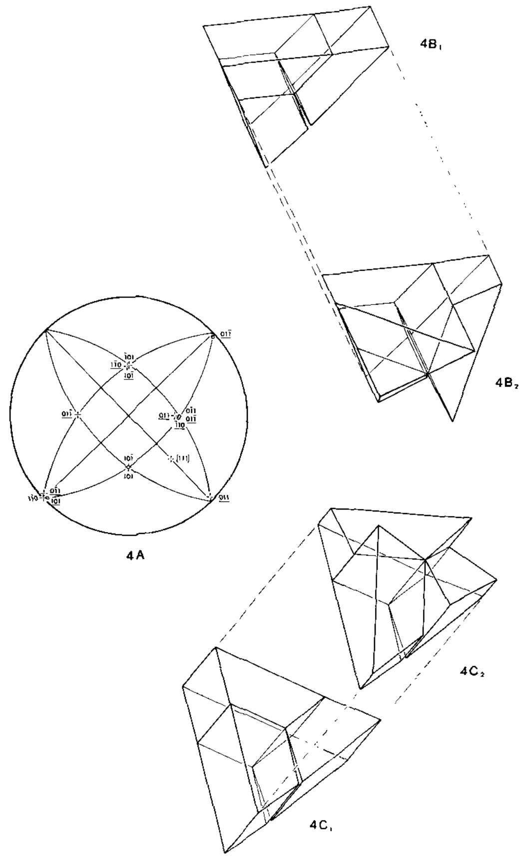

FIG. 4A. Stereographic projection, with individual I in the standard setting of tetragonal crystals, showing all the faces developed on a pseudotrigonal contact triplet. -¦- represents faces on the upper half sphere, ⊙ represents faces on the lower half sphere, and -⊕- represents faces on both the upper and lower half spheres. B_1. Drawing of a section perpendicular to [111] of an idealized triplet of tugtupite, orthographic projection || *c*-axis of individual I. B_2. Drawing of the top of an idealized triplet of tugtupite, orthographic projection || *c*-axis of individual I. C_1. Clinographic projection of B_1. C_2. Clinographic projection of B_2.

In fig. $4C_1$ and C_2 are shown the clinographic projections ($\theta = 18° 46'$, $\varphi = 9° 28'$) corresponding to the two orthographic projections.

It will have been noticed that the triplet has been described as a symmetric twin; it should be emphasized, however, that the present triplet could equally well have been described as a hemitrope twin. Such a description would induce equally simple, but obviously other, indices for the faces developed.

Conclusion. The pseudotrigonal contact triplets described show several remarkable features.

First of all, tetragonal crystals forming twins with a distinct pseudotrigonal habit are, if ever reported, very rare.

Mimetic twins of tetragonal crystals are most often pseudocubic, twins of tetragonal hemi- or tetartohedral crystals are normally confined to supplementary twins, and twinning, with the normal to a 'dodecahedral face' as twin axis, of pseudocubic crystals, normally produces some kind of a pseudohexagonal habit.

It should further be noticed that the pseudotrigonal habit has been obtained only because the faces developed on individual I and on individuals II and III are, although all belonging to the same two forms, not the same:

Individual I ($\bar{1}01$), ($1\bar{1}0$), ($10\bar{1}$), ($01\bar{1}$), (101).

Individuals II and III ($10\bar{1}$), ($01\bar{1}$), ($0\bar{1}1$), ($\bar{1}10$), (011).

And because the proportion between the lengths of the traces of the faces ($\bar{1}01$) individual I and ($0\bar{1}1$) individuals II and III in a plane perpendicular to the pseudo-threefold axis ($\perp$ to [111] individual I) and the traces in the same plane of all other faces constituting the pseudo-threefold prism is 2:1.

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REFERENCES

Danø (M.), 1966. The crystal structure of tugtupite—a new mineral, $Na_8Al_2Be_2Si_8O_{24}(Cl, S)_2$. *Acta Crystallogr.* **20**, 812–16.

Sørensen (H.), 1960. Beryllium minerals in a pegmatite in the nepheline syenites of Ilímaussaq, South West Greenland. *Rep. 21st Int. geol. Congr., Norden*, **17**, 31–5.

—— 1963. Beryllium minerals in a pegmatite in the nepheline syenites of Ilímaussaq, South West Greenland. Ibid. **27**, contributions to discussions, 157–9.

—— Danø (M.), and Petersen (O. V.), 1971. On the mineralogy and paragenesis of tugtupite, $Na_8Al_2Be_2Si_8O_{24}(Cl,S)_2$ from the Ilímaussaq alkaline intrusion, South Greenland. *Meddr. Grønland*, **181**, 13, 1–38.

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