CONTRIBUTIONS TO THE MINERALOGY OF NORWAY

No. 31. Tysonite (fluocerite), a new mineral for Norway

BY

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Abstract. Tysonite is reported from the granite-pegmatite, Jennyhaugen, Drag in Tysfjord, Nordland county, Northern Norway, and from granite-pegmatite at Höydalen, Tördal in Telemark county, Southern Norway. Optical and X-ray data are given. The parageneses of the two tysonites are described and their genesis is discussed.

Introduction

After completing our paper on bastnäsite in Norway (SVERDRUP, BRYN, SÆBÖ 1959), tysonite and bastnäsite were found in the granite-pegmatite, Jennyhaugen at Drag in Tysfjord, Nordland county, Northern Norway. This is the first occurrence of tysonite (= fluocerite) in Norway.

NEUMANN and BERGSTÖL (1963) mention the discovery of törnebohmite and fluocerite, and say: 'As far as the authors are aware not only cerianite, but also törnebohmite and fluocerite are new to Norway.' However, the prior claim of the Jennyhaugen tysonite occurrence can be clearly established, since our discovery was mentioned in 1959 in NEUMANN's (1959) introduction to this series of mineralogical papers.

Shortly afterwards, tysonite was also identified from the granite-pegmatite, Höydalen, Tördal in Telemark county, Southern Norway. (See the key map, Fig. 1.)

GEIJER (1921) gave a short summary of the early history of the mineral fluocerite (= tysonite), (Ce, La)F_3. The mineral was first described by BERZELIUS (1818) from the granite-pegmatite of Finnbo

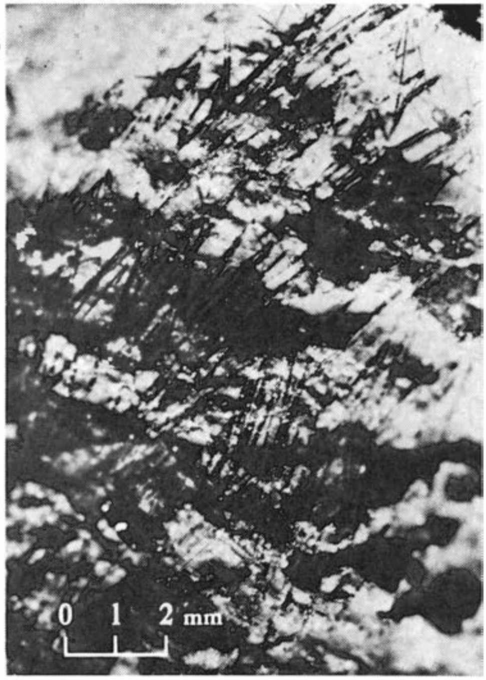

Fig. 1. Key map showing the localities of the pegmatites. 1. Jennyhaugen, Drag in Tysfjord. 2. Tördal in Telemark.

Fig. 2. Crystal aggregate with tysonite (a dull ground mass) and bastnäsite (needles), from Jennyhaugen.

and Broddbo near Falun, Sweden. The name fluocerite was given it by HAIDINGER (1845).

The mineral from Broddbo was later examined by NORDENSKJÖLD (1870) and FLINK (1910). ALLEN and COMSTOCK (1880) described a fluoride of cerium earths (Ce, La, Di)F_3 from a granite-pegmatite in Cheyenne Canyon in the Pikes Peak region of Colorado, which they called tysonite.

A few years later fluocerite was discovered in a granite-pegmatite at Österby, Dalarne, Sweden. This mineral was described by WEIBULL (1886, 1890, 1898), who came to the conclusion that it was an oxy-fluoride with the formula (Ce, La, Di)$_2$OF_4.

GEIJER (1921) restudied the type material from the Swedish localities. He found that the properties of the Swedish fluocerites were identical with those of the tysonite described by ALLEN and COMSTOCK (1880). Geijer preferred the name fluocerite for the sake of priority.

The name fluocerite has been used by some authors. STRUNZ (1957), however, prefers the name tysonite, because the name fluocerite is somewhat misleading.

We share the opinion of Strunz, and the name tysonite is used in this work.

The tysonite structure was first investigated by OFTEDAL (1929, 1931) by means of Laue-powder and oscillation photographs. The mineral was found to be hexagonal, $c_0 = 7.280$ Å, $a_0 = 7.124$ Å with a pseudocell $c = c_0$ and $a = \frac{a_0}{\sqrt{3}} = 4.11$ Å.

SCHLYTER (1953) restudied the tysonite structure by means of Weissenberg-photographs, and came to the conclusion that the pseudo-cell of Oftedal was the true cell. Further, Schlyter determined the probable space-group $D_{6h}^4 - P\,6_{3/mmc}$ and $Z = 2$. Oftedal studied the tysonite from El Paso, while Schlyter used the Österby tysonite in his studies.

Tysonite from Jennyhaugen, Drag in Tysfjord

Geology

Jennyhaugen is one of the largest granite-pegmatites in the Drag district. The deposit has been quarried almost continuously since 1910. The pegmatites in this district consist of soda-rich microcline and quartz. They are characterized by rather fine-grained, pure masses of microcline and albite along the peripheral parts of the body, often with lenses of quartz, and veins containing fluorite. Large, pure masses of quartz and microcline are often present in the more central parts of the pegmatites.

The Jennyhaugen pegmatite is a thick, lens-shaped body, partly conformable to the surrounding, nearly vertically dipping, gneissoid Tysfjord granite, here striking N 240°.

The Tysfjord granite has been treated by FOSLIE (1941), REKSTAD (1919), and VOGT (1922).

The Jennyhaugen pegmatite has been mapped and described by SVERDRUP and SÆBÖ (1958). Fig. 3 shows the dimensions and general characteristics of the pegmatite and its quarries.

The material

Our material consists of a crystal aggregate containing the minerals tysonite, bastnäsite, and yttrofluorite.

The tysonite has a dull, yellow to brownish colour without external crystal form. The bastnäsite occurs as needles and plates in subparallel arrangement within the tysonite (Fig. 2) and is light yellow and transparent. It is well crystallized. The greyish white yttrofluorite occurs frequently as minute isotropic grains within the tysonite mass.

Separation and identification of the minerals

Tysonite, bastnäsite and yttrofluorite are all heavy minerals, which, after crushing, were isolated from the feldspars and quartz by means of heavy liquid (acetylenetetrabromide). These heavy minerals were then separated with a Franz isodynamic magnetic separator.

The tysonite containing yttrofluorite was found to have very similar magnetic properties to bastnäsite. Both minerals fell into the magnetic fraction in the range 0.4–0.6 mA, but tysonite was enriched in the field 0.6 mA, thus enabling separation by repeated fractionation.

The minerals were identified by their X-ray powder patterns.

The intergrowth between the tysonite and yttrofluorite made it impossible to isolate pure fractions of these two minerals by the methods described above. It was, however, easy to distinguish between the two minerals by means of X-ray powder photographs as demonstrated in Table 1.

The optical and crystallographical data of the tysonite and bastnäsite are given in Table 2.

Tysonite appears rather cloudy under the microscope; therefore, the optical determinations are not accurate. The intimate intergrowth with yttrofluorite has made it very difficult to determine its optical character. The determinations of the refractive indices, however, are in agreement with those of an optically negative mineral. It is therefore concluded that the tysonite from Jennyhaugen is uniaxial negative.

Tysonite from Höydalen, Tördal in Telemark county

Geology

The granite-pegmatite dikes in the Höydalen area have been treated by Oftedal (1942). The locations of the pegmatites in the area can be seen in his publication. These dikes are the only lepidolite-cassiterite bearing pegmatites hitherto found in Norway.

The general description of the pegmatite, given by Oftedal, is: 'The pegmatite is a cleavelandite-quartz-pegmatite replacing amazonite-pegmatite and occurs in the shape of small dikes, 4 to 5 metres across, cutting gabbro and crystalline schists near the boundary of the younger Telemark granite.'

Oftedal examined the following minerals from the primary amazonite-pegmatite: amazonite, spessartite, albite, and gadolinite. From the cleavelandite-pegmatite the following minerals were examined: cleavelandite, topaz, lepidolite, beryl, cassiterite, monazite, yttrotantalite, microlite, and alvite. The pegmatite should then be of low-temperature formation (BJÖRLYKKE 1953).

RAMBERG (1942), who visited the same pegmatite in the autumn of 1942, came across a small lump of a yellow mineral in cleavelandite in a small pit, just a few metres north of the easternmost of the quarries. The mineral was shown to be rich in rare earth-elements and fluorine, and he suggested it to be fluocerite. The finding of this material was the first indication of the presence of tysonite in Norway, and our investigations have confirmed Ramberg's suggestion.

During a visit to the quarries in the summer of 1961 more recent blasting in the western part of the quarries had revealed a massive zone of fine-grained lepidolite surrounded by large books of lepidolite up to 30 cm in diameter. Within this lepidolite zone several remnants of spessartite-crystals belonging to the primary amazonite-pegmatite were found. Closely associated with these garnets was a unique collection of rare earth-fluorides and silicates, of which only the tysonite and associated minerals will be discussed here.

The material

The type of material is closely related to the material from Jennyhaugen. Tysonite is also here intergrown with yttrofluorite, and it is impossible to isolate the two minerals from each other by heavy liquids or magnetic separation.

On an X-ray powder photograph, however, both of the structures are well developed.

The isotropic yttrofluorite is also easy to recognize under the microscope.

Table 1. Decreasing

Bastnäsite Lapplegret		Yttrofluorite Hundholmen			Tysonite, data after ASTM. OFTEDAL (1929)		
d	I	d	hkl	I	d	hkl	I
4.83	m						
					3.62*		
3.52	st				3.53*		
					3.20	101	st
		3.18	111	st			
2.86	vst				2.84_5*		
		2.75_1	200	w			
					2.53*		
2.41	vw						
2.05	st				2.06	110	m
2.00	st				2.01	103	st
		1.94_6	220	st			
1.88	m						
					1.79	112	m
1.76	vw						
					1.73	201	m
1.66	w	1.66_3	311	m			
1.56	w						
1.47	w						
1.43	w				1.44	203	st —
		1.37_6	400	w	1.37	114	m
1.34	vw				1.35	105	m +
						210	
					1.33	211	st
1.29	vw						
1.27	vw	1.26_6	331	w			
		1.26_6	420	w			
					1.21	006	vw
1.17	vw				1.18	213 (115)	st
1.15	w				1.15	106	w
		1.12_7	422	m	1.13	205	st
1.04	vw	1.06_2	330 (511)	w	1.04	116	m +
					1.03	220	w
					0.991	222	
					0.988	215	st
					0.980	311	m

intensities: vst – st – m – w – vw

X-ray data

Tysonite Jennyhaugen			Tysonite Jennyhaugen			Tysonite Tördal		
d	hkl	I	d	hkl	I	d	hkl	I
4.82	?	vw						
3.62	002	w	3.65_3	002	w	3.66	002	w
3.54_5	110	w	3.56_5	100	w	3.59_3	100	m
3.19_7	101	st	3.20_7	101	vst	3.19	101	st
			3.16_3	+	st	3.16_5	+	m
2.85_9		w	2.87_1		vw	2.87		w
			2.74_0	+	vw	2.73	+	w
2.53_9	102	vw				2.55_2	102	w
2.05_5	110	st	2.06_0	110	st	2.05_8	110	m
2.00_7	103	vst	2.01_6	103	st	2.00_3	103	m
			1.93_3	+	st	1.91_9	+	m
1.89	?	vw						
1.79_4	112 (004)	w	1.79_9	112 (004)	w	1.79_4	112	m
1.73_7	201	vw	1.73_4	201	vw	1.73_3	201	w
1.66_9	104	vw	1.65_1	+	w	1.64_5	+	m
1.44	203 (005)	w	1.44_2	203 (005)	vw	1.43_7	203	w
1.36_8	114	vw	1.36_8	114	vw	1.36_2	114	w
1.32_9	105	vw	1.32_8	105	vw	1.32_7	105 (211)	
1.29_4	(204)	vw						
			1.25_5	+	vw	1.25_7	+	w
			1.22_6	+	vw	1.21_8	+	w
			1.22_6	006	vw	1.21_8	006	w
1.18_2	213	vw				1.18_9	115 (213)	
1.15_1	106	vw						
1.13_3	205	vw	1.11_7	205	vw	1.11_5	205	vw
			1.05_3	116	vw	1.05_4	116	vw

* Characteristic lines on an X-ray powder pattern of tysonite, Österby, Dalarne, Sweden.

? Lines which signify some bastnäsite in the powder.

\+ Lines which signify yttrofluorite.

The tysonite from Tördal has a dull brown colour and is partly intergrown with a pure yellow monazite.

In one area, where no monazite is identified, the outer shape of the tysonite resembles that of monazite, and we conclude, therefore, that the tysonite has been formed pseudomorphically after monazite.

The optical data are given in Table 2.

X-ray data

The X-ray powder pattern of the tysonite from Tördal is virtually identical to that from Jennyhaugen, and after subtraction of the lines of yttrofluorite (d = 3.16, d = 1.93, d = 1.66 and others) both are identical to the tysonite from Österby, Dalarne, Sweden. (See Table 1.)

Discussion

STEYN (1961) reports a new discovery of tysonite from Mutue Fides, Potgietersrus District of the Transvaal. He discusses the physical, optical, and chemical properties of fluorites and tysonites given in the literature and arrives at the conclusion that there exists a difference between the Colorado-type of the mineral (Ce, La-)F_3 and the Österby-type, which, according to Weibull, is an oxyfluoride (Ce, La-)$_2OF_4$.

STEYN (1961) proposes that the name tysonite should be applied to the uniaxial negative fluoride (Colorado-type) and the name fluocerite should be applied to the uniaxial positive mineral, which probably is an oxyfluoride (Österby-type).

Unfortunately there have been conflicting reports on the optical data of Steyn's type locality fluocerite. Weibull stated that the Österby mineral was uniaxial positive $\varepsilon - \omega = 0.002$. On the other hand GEIJER (1921), who studied the original material of Weibull, clearly states that the Österby material is uniaxial negative with higher birefringence than given by Weibull. Both Weibull and Geijer stress the fact that the material from Österby is strongly altered into several secondary minerals.

From the Mineralogical-Geological Museum, Oslo, we received tysonite material from Österby, Dalarne. We have made X-ray powder photographs as well as optical studies of the material. The material studied is uniaxial *negative*. The X-ray data are given in Table 1.

Table 2. *Crystallographical and optical data*

Locality	a_0	c_0	a	c	c/a	ε	ω	±
Bastnäsite[1]	4.13	4.89	7.16_2	9.28_7	1.37_6	1.815–1.8242	1.713–1.7225	+
Tysonite[2], W. Cheyenne Canyon, Colorado	4.112	7.280	7.124	7.280	1.022	1.607[3] –1.611	1.612[3] –1.618	—[3]
Tysonite, Jennyhaugen, Drag	$\approx$4.115	$\approx$7.290	$\approx$7.128	$\approx$7.290	1.022_7	1.610	$\gtrsim$1.610	—
Tysonite, Tördal	$\approx$4.12	$\approx$7.3	$\approx$7.136	$\approx$7.3	1.022_9	1.610	$\gtrsim$1.610	—
Bastnäsite, Jennyhaugen, Drag						$\lesssim$1.820	1.719	+
Bastnäsite, Hundholmen ...						1.820	1.719	+

[1] DONNAY and DONNAY 1953.
[2] OFTEDAL 1929.
[3] WINCHELL 1961.

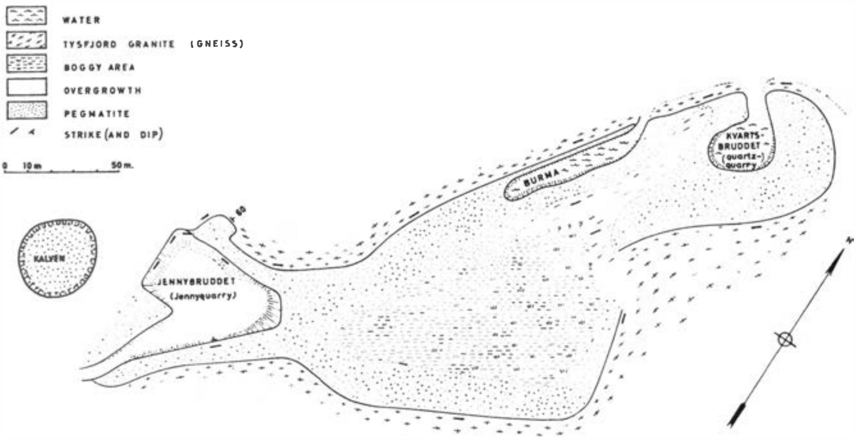

Fig. 3. Jennyhaugen pegmatite, Drag in Tysfjord.

The analyses given by Weibull were performed on bulk material, and no attempt was made to concentrate the pure unaltered mineral. It is therefore highly probable that the oxyfluoride (Ce, La-)OF_4 given by Weibull only reflects the degree of alteration of the material as suggested by PALACHE *et al.* (1951).

The data quoted by Steyn for the Österby material are therefore not reliable.

In 1945 a rare earth-fluoride was discovered in a pegmatite at Mpuye Hill near Mubende in the then Protectorate of Uganda. According to STEYN (1961) the material was reported by Roberts in 1945 and 1946 and analyzed by Bennet, who calculated its formula as $(Ce, La, Di)_2O_{0.4}F_{5.2}$. Steyn quotes Roberts as saying that this mineral is also uniaxial positive and therefore cites it as a second occurrence of 'fluocerite'.

The papers by Roberts have not been available to us, and we therefore do not know the purity of the material analyzed by Bennet. As shown above, however, the sum total of evidence for the Österby material suggests that it is a mixture of primary tysonite (Ce, La-)F_3 and several alteration products. One possible impurity could be cerianite, which would increase the Ce-content in the mineral, and, consequently, an oxyfluoride must be postulated. Such a mineral association was found by NEUMANN and BERGSTÖL (1963) in the Iveland pegmatites. It is therefore most likely that the 'oxyfluoride' is not a mineral, but a mixture of tysonite and several alteration-products in such an intimate intergrowth that it is impossible to isolate the various minerals for identification.

In our opinion the existing data are insufficient to establish the existence of an oxyfluoride mineral. The Österby material should be re-investigated more carefully before any final conclusion can be drawn. Further, the name fluocerite is still somewhat misleading, and if the existence of the oxyfluoride should be definitely proved by further investigations, the name oxytysonite would be more appropriate than fluocerite.

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