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CRONSTEDTITE FROM CHYŇAVA – ČSSR

Small druses of lustrous black minute crystals of cronstedtite were encountered in a steep quartz-calcite veinlet penetrating the conglomeratic sandstones of the Tremadocian Třenice Formation in the bore Craelius A-4 CE of Chyňava near Beroun. A brief description is given of the geology of the area, the bore profile (F. Fiala) and mineralogical characteristic of the cronstedite (J. Kouřimský).

Ve strmé kalcitové žilce, pronikající slepencovité pískovce třenických vrstev (tremadok) ve vrtu Craelius A-4 jv. od Chyňavy u Berouna byly v r. 1944 zastiženy drobné drúzy leskle černých krystalků cronsteditu. Stručně jsou uvedeny geologické poměry okolí a geologický profil vrtu (F. Fiala) a zjištěné mineralogické vlastnosti cronsteditu (J. Kouřimský).

INTRODUCTION

Cronstedtite, a rare Fe·· Fe··· leptochlorite, has been described from a very restricted number of Bohemian localities only, i. e. from the Vojtěch Mine in Příbram (the first known occurrence in the world. — J. STEINMANN 1820 in cooperation with F. X. M. ZIPPE), from Kutná Hora (K. VRBA 1886, 1901, J. BARVÍŘ 1903) Kaňk near Kutná Hora (F. NOVÁK et al. 1957), Litošice and Sovolusky (F. NOVÁK and V. HOFFMAN 1956) and Chvaletice (F. NOVÁK and J. JANDA 1965). The last three localities as well as that of Semtěš belong to the region of the Železné hory Mts.

A cronstedtite from Semtěš, collected by J. V. FRIČ and deposited under inv. no 74 127 in the collections of the department of Mineralogy and Petrography of the National Museum (Natural History), Prague, is now being investigated by J. KOUŘIMSKÝ. The cronstedtite described by F. A. KOLENATI (1854) from Zlaté Hory in Silesia is considered by T. KRUŤA (1973) to be some other mineral of the chlorite group.

A further cronstedtite locality has been reported by F. FIALA (1951, p. 4 and 35) from the base of the bore Craelius A-4 drilled during 1943 to 1944 by the then Pražská železářská společnost (Prague Iron Co.) SW of the village of Chyňava about 7 km N of Beroun. A steep quartz--rimmed veinlet of white crystalline calcite enclosing grains and aggregates of pyrite was encountered in the sandstones of the Tremadocian Třenice Formation underlying a Lower Ordovician volcanogenic suite of diabase volcanics and pyroclastics. Steep fissures in the veinlet were filled with druses of minute hemimorphous pyramidal crystals of lustrous black cronstedtite. Because of other urgent tasks, no separate report on this cronstedtite was elaborated at the time of its discovery, and the cronstedtite-bearing bore-core (inv. no. 54 444) was transmitted to J. KOUŘIMSKÝ of the mineralogical department of the National Museum for checking and further investigation. J. KOUŘIMSKÝ confirmed F. FIALA'S determination of the mineral, and mentioned this cronstedtite merely in the list of minerals from the Chyňava locality, included in the Topographical Mineralogy of Bohemia by J. KRATOCHVÍL (IInd part, 1957—1966).

A separate report on this interesting occurence of cronstedtite at Chyňava was therefore compiled by both authors of this paper and is presented here.

GEOLOGICAL SETTING

The bore Craelius A-4 was drilled by the Pražská železářská společnost (Prague Iron Co.) in a field about 1 km SE of the village of Chyňava. The environs of Chyňava belong geologically to the eastern part of the north--western limb of the Lower Paleozoic syncline of the Barrandian Basin and its Proterozoic basement represented here by its monotonous facies with local occurences of silicites (J. CHÁB 1965). The boundary between the Proterozaic and Lower Paleozoic (Ordovician) is considerably straight, running SW—NE from Stradonice in the SW, toward the NE, through the south-eastern surroundings of Chyňava, to Libečov. The base of the Ordovician sequence dipping south-eastward is formed of a narrow strip of conglomerates, sandstones and greywackes of the Tremadocian Třenice Formation observable on the surface only in some places. The overlying sharply bounded volcanogenic series is represented by a sequence of diabase tuffs and tuffites and minor diabase effusions (Arenig), and by a superposed suite of amygdaloidal and aphanitic diabases, diabase porphyrites, weilburgites, weilburgite peperites and sporadic shale interbeds of the Llanvirn. The thickness of this volcanic series ranges, W of Libečov, between 300—600 m; it diminishes strongly eastwards, then being only 45 m thick in the Chrbina Gallery (J. KREJČÍ and R. HELMHACKER 1885, p. 28).

Geological section of the bore Craelius A-4 at Chyňava

The bore, 203 m deep, penetrated between 0.00—165.30 m the Llanvirnian volcanic suite with overwhelming diabase and weilburgite volcanics with sporadic interlayers of shales and sandy argillites containing hematite oolites and nests (between 32.70—34.25 m; 94.15—96.70 m; 111.00—112.60 m). Underlying this suite, between 165.30—188.00 m, a sequence of tuffs, tuffites, amygdaloidal diabases and shales of the Arenig (Skiddaw) was encountered. Underneath, between 188.00—203.00 m, a sequence of Tremadocian tuffites, sandstones, greywackes and conglomerates of the Tremadocian Krušná Hora Formation followed. Here, at a depth of 202 m, the above-mentioned calcite veinlet with cronstedtite was encountered.

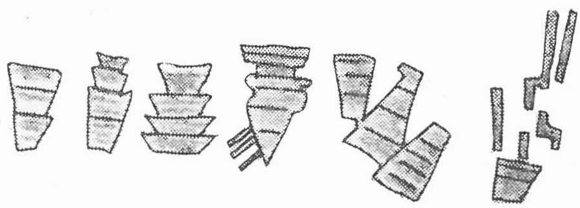
A brief record of the bore profile is given below (compare also F. Fiala 1951, p. 4 and 9—10).

0.00— 11.20 m	effusive amphibole diabase, amygdaloidal in its marginal parts,
11.20— 12.50 m	greenish light-grey fine-grained diabase tuff,
12.50— 20.50 m	weilburgite peperite (F. Fiala 1971, p. 37 and 85; in F. Fiala 1951 p. 3 and 21 — „explosive tuffaceous weilburgite breccia"),
20.50— 21.80 m	compressed diabase tuff („Schalstein"),
21.80— 32.70 m	amygdaloidal diabase porphyrite, grey-green to reddish-grey,
32.70— 34.25 m	sandy claystone with hematite oolites and nests,
34.25— 94.15 m	aphanitic diabase porphyrite, greenish black with amygdaloidal rims and with an amygdaloidal dykelet between 55—57 m,
94.15— 96.70 m	sandy claystone with hematite oolites and nests,
96.70—106.00 m	albite-oligoclase (spilitic) porphyrite, amygdaloidal in its upper part,
106.00—109.00 m	weilburgite-peperite (as between 12.50—20.50 m),
109.00—111.00 m	amygdaloidal diabase porphyrite,
111.00—112.60 m	dark grey shale of the Lower Šárka shales (Lower Llanwirn),
112.60—118,00 m	weilburgite peperite (as between 12.50—20.50 m),
118.00—160.50 m	sequence of diabase to diabase-porphyrite tuffs and tuffites, occasionally with subordinate interlayers of shale, partly containing chlorite-, locally also hematite oolites.
160.50—165.30 m	porphyritic weilburgite, partly amygdaloidal, perhaps a shallow intrusion,
165.30—188.00 m	tuffaceous breccia, tuffites, greyish red shales, amygdaloidal diabase and variegated tuffs (Arenig-Skiddaw),
188.00—203.00 m	sandstones, tufaceous sandstones, tuffs and shales of the Tremadocian Krušná Hora Formation. Here, the following layers have been distinguished:
188.00—190.00 m	fine-grained greenish tuffaceous sandstones; slightly compressed,
190.00—190.60 m	variegated tuffs, violetish dark grey, finegrained, compressed,
190.00—195.60 m	greenish tuffaceous sandstones (as between 188.00—190.00 m) grading locally into tuffites or silicic sandstones. They contain fragments of red shales, quartzites etc.,
195.60—196.00 m	alternation of green sandstones and ruddy shales,
196.00—203.60 m	conglomeratic and sandy shales of the Třenice Formation with grains of quartz, silicites and sporadic perlitic glass and with quartzose cement. At 202 m a steep veinlet of white crystalline calcite with slightly quartzose marginal zones was encountered, enclosing grains and aggregates of pyrite, the steep fissures being coated with druses of minute lustrous black crystals of cronstedtite.

CRONSTEDTITE IN THIN SECTIONS

The central part of the veinlet consists of calcite grains ∅ 1—3 mm, locally in radial arrangement. In the marginal zones of some major calcite grains, often greyish turbid, very fine scales of brown-green chlorite are grown in. Between calcite grains, interspersed nests and clusters of massive pyrite (0.05×0.2 to 1.2×2.5 mm), sometimes showing a tendency to cubic shapes, occur together with frequent minute hemimorphous crystals (0.02×0.05 to 0.2×0.4 mm) of cronstedtite sitting on the pyrite and growing both into the pyrite and into the margins of calcite grains.

The Chyňava cronstedtite occurs in some places as irregular clusters of very fine opaque black scales and tablets. Elsewhere it forms conspicuous groups of inverted low frusta of pyramids up to rods, often skeletal, growing perpendicularly one above another and dissected by well marked basal cleavage (see fig.). Frequent are groups of prolonged sharp pyramids and rods, sometimes in radial arrangement. The crystals show a distinct vertical striation and a strong resinous luster on basal cleavage planes. They are relatively soft, well soluble in concentrated HCl.



Some shapes of the cronstedtite from Chyňava in polished sections

OPTICAL PROPERTIES

In the powder under the microscope, cronstedtite appears as scales, fine rods and minute wedges, showing excellent cleavage. They show very strong absorption. In the direction of length and cleavage, they are perfectly opaque and black, in the perpendicular direction sometimes being sligthly dark-brown to brown-black translucent. The colour of the crystals being very intense, it is impossible to determine their optical constants inclusive of double refraction and character of length. Their extremely high indices of refraction may be observed at the very thin edges of some individuals in mixtures of highly refractive bromides and sulphides of arsenic, antimony and selenium. Double refraction too is evidently very high. In the above-mentioned immersion medium, even signs of pleochroism (opaque to dark-brown × red-brown to green-black) may be observed on the very thin margins of some individuals.

X-RAY DETERMINATION

The X-ray determination was carried out using the Debye-Scherrer method on a Mikrometa II apparatus (camera ∅ 53.7 mm, $CuK_{\alpha1.2}$ radiation, Ni filter). 40 kV voltage, 20 mA intensity, exposure 240 min. Table no 1 shows the values d, and the intensities of the mineral examined are compared with analogous data of the cronstedtite from Sovolusky, given by F. Novák and V. Hoffman (1956), and with those of the cronstedtite from Cornwall given by F. A. BANNISTER in B. HALLIMOND (1939). The lines are in a comparatively very good agreement.

Tab. No 1 d — spacings of cronstedtites from Chyňava, Sovolusky, Kutná Hora and Cornwall

	Chyňava		Sovolusky 1		Kutná Hora 1		Cornwall 2	
	I rel	d in (Å)	I rel	d in (Å)	I rel	d in (Å)	I rel	d in (kX)
1	2 dif.	10,18						
2	2 dif.	8,44						
3	1	7,52						
4	10	6,99	vs	7,09	vs	7,09	10	6,72
5	1	3,63	vvw	4,74	vvw	4,74	1	4,62
6	9	3,53	vs	3,57	vs	3,56	9	3,49
7	3	2,70	vw	2,72	m dif.	2,72	7	2,70
8	4	2,57	mw	2,57	mw	2,57		
9			vvw	2,51	m	2,51	7	2,41
10	5	2,37	vvw	2,42	vvw	2,42		
11			vvw	2,35	vvw	2,35	1	2,33
12	1	2,18	vvw	2,18	vvw	2,29	1	2,27
13	5	1,986	vvw	2,05	mv	2,03	5	2,02
14			vvN	1,967	vvw dif.	1,974	1	1,96
15	1	1,801	vw	1,906	vvw dif.	1,912		
16			mw	1,734				
17	3	1,644	vvw dif.	1,687	vw	1,689	4	1,67
18	2	1,594	mw	1,590	mw	1,588	8	1,58
19	1	1,552	vw	1,554	vw	1,554	4	1,55
20	2	1,498	vw	1,499	vw	1,507		
21	1	1,454	vvw	1,444	vvw	1,446	4	1,44
22	1	1,418						
23	1	1378	mw dif.	1,399	mw dif.	1,404	1	1,37
24			vw dif.	1,364	vw dif.	1,369		

1) NOVÁK, F., HOFFMAN, V. (1955): Fe $K_{\alpha 1,2}$ radiation, filtered through Mn. Debye--Scherrer, camera ∅ 114,8 mm.

2) HALLIMOND, A. F., BANNISTER, F. A. (1939): unfiltered Co $K_{\alpha 1,2}$ radiation, radius of camera 30,2 mm.

CHEMICAL DETERMINATION

The polished section of the cronstedtite from Chyňava was analyzed in two points using a JOEL/JSX/50A electron microprobe. The average results obtained from 4 measurements in each of the two points are as follows:

$$\text{Fe} — 36.38\% \ (\Sigma \ \text{Fe}^{\cdot\cdot} \text{ and Fe}^{\cdot\cdot\cdot})$$
$$\text{Si} — 3.98\ \%.$$

In evaluating these results it is necessary to start from the assumption that during the electron microprobe analysis a considerable amount of H_2O volatilizes, so that in the case of an analysis of cronstedtite, the Fe:Si ratio is important, and not their absolute content determined by the analysis. In the case of the Chyňava cronstedtite, the Σ Fe:Si ratio = 9.14.

In the chemical formula of the cronstedtite

$$Fe_4^{\cdot\cdot} Fe_2^{\cdot\cdot\cdot} (OH)_8 Fe_2^{\cdot\cdot\cdot} Si_2O_{10},$$

theoretically 55.92% Si are assumed, i.e. the Σ Fe:Si ratio = 7.95. However the chemical composition of cronstedtite from various localities varies considerably as may be seen in table 2, where chemical analyses of the cronstedtite from Příbram and Kutná Hora are given. The table reveals that especially the cronstedtite from Příbram has an extremely high SiO_2 content, i. e. much higher than would correspond to the theoretical chemical composition. The contents of Fe and Si were calculated as the means of four analyses II—V. Analysis I was not taken into consideration, as its revision is contained in analysis II. In contrast, the cronstedtite from Chyňava has an very low content of SiO_2.

Tab. No 2. Chemical analysis of cronstedtites

		I.	II.	III.	IV.	V.	VI.	
	Teor.	Příbram					K. Hora	Chyňava
SiO_2	15,04	22,45	22,45	21,39	21,30	22,21	17,34	
Fe_2O_3	39,97		35,35	29,08	32,34	37,49	43,05	
FeO	35,97	58,85	27,11	33,52	29,23	25,28	30,27	
MnO		2,89	2,89	1,01	1,25	1,20	0,16	
MgO		5,08	5,08	4,02	4,51	5,23		
H_2O	9,02	10,70	10,70	9,76	11,90	8,27	9,18	
	100,00	99,97	103,58	98,78	100,53	99,68	100,00	
ΣFe	55,92	45,85					53,64	
Fe:Si	7,75	10,21					8,11	
Si	7,95	4,49					6,61	9,14

Authors of analyses:

I. J. J. STEINMANN (1820),
II. Fe_2O_3/FeO derived from I. by F. KOBELL - Schweiggers Journ., 62 (1831), str. 196,
III. A. DAMOUR. Ann. chim. et phys., 58 (1860), str. 99,
IV. J. V. JANOVSKÝ (1875),
V. U. LUDWIG u G. TSCHERMAKA. Tschermaks mineral. petrogr. Mitt., 12 (1891), str. 32,
VI. ROSAM u K. VRBY. Sitz.-Ber. böhm. Gesell. Wiss., 15. I. (1886).

GENESIS

The genesis of cronstedtite has hitherto been interpreted as a transformation and replacement of the pyrite which is always associated with cronstedtite. This mode of origin of cronstedtite was stated for the first time by A. E. REUSS (1856) on the cronstedtite from Příbram. The cronstedtite derived from the Chyňava locality also arose later than pyrite as may be well observed on thin sections, an particularly on the photographs taken by an electron microprobe. In the Chyňava sample the cronstedtite aggregates attaining thicknesses of up to 5 mm adjoin calcite containing impregnotions of pyrite. The cronstedtite sits on and penetrates into the pyrite crystals along cracks, partly replacing it. In the crystallization of cronstedtite, part of Fe was clearly taken up from the replaced pyrite. In thin sections it is unequivocally recognizable that the minute cronstedtite crystals enclosed in the margins of the calcite grains crystallized entirely independently.

The problem of the origin of cronstedtite in diverse localities is being studied by the authors of this paper in cooperation with Dipl.-Ing. D. Rykl, CSc. of the Geological Institute of the Czechoslovak Academy of Sciences, who is the author of the electron microprobe photographs shown in this paper.

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EXPLANATIONS OF THE TABLES

Pl. I.

Fig. 1. Cronstedtite from Chyňava. Radially arranged rods and tablets sitting on and rimming the pyrite crystals in the calcite veinlet. Boundary between opaque cronstedtite and pyrite not discernible. — × 20.

Fig. 2. Rads, hemimorphous tablets and frusta of pyramids of the cronstedtite from Chyňava in the calcite veinlet. — × 50.

Pl. II.

Fig. 1. Skeletal crystals of cronstedtite in the calcite veinlet. — × 50.

Fig. 2. Tablets and frusta of pyramids of the cronstedtite growing one above another. — × 130.

Pl. III.

Electron photomicrographs of polished section: cronstedtite — grey, pyrite — light grey, calcite — black. — × 100:

Fig. 1. Edax — quantitative analyse — Fe,

Fig. 2. Edax — quantitative analyse — S.

Pl. IV.

Scanning photographs of this polished section:

Fig. 1. distribution of Σ Fe,

Fig. 2. distribution of S.

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Note: Papers marked * were not at the authors' disposal. They are mentioned only according to quotations.