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ANILITE, Cu_7S_4 , FROM LUBIN MINE, LOWER SILESIA POLAND

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Abstract. Within the limits of measuring accuracy, anilite from the Lubin mine has the lattice parameters identical with those of anilite from the Ani mine. They are: $a = 7.90 \pm 0.02$, $b = 7.82 \pm 0.02$, $c = 11.00 \pm 0.02$. Its chemical composition is also similar, corresponding to the formula Cu_7S_4 , the only difference being a 0.27 wt. % Fe admixture. Anilite from the Lubin mine is mainly confined to the boundary dolomite, occurring there in two parageneses: as lamellae in djurleite, or independently, in the form of elongate columnar crystals in the nests of secondary carbonates. In the latter case, it is commonly accompanied by a mineral $\text{Cu}_6\text{FeS}_5(?)$, showing identical morphological features and optically resembling bornite.

INTRODUCTION

The principal ore minerals of the copper deposits of the Fore-Sudetic Monocline are chalcocite, digenite, bornite, covellite, chalcopyrite, tennantite. Djurleite (Harańczyk, Jarosz, 1973) and *blueremainder* covellite were also found in the deposits. From the present studies it appears that anilite should be placed in this group as well. In places, anilite is one of the principal Cu minerals.

METHODS

Electron microprobe analysis was carried out on Cameca MS-46 (sample 65) and ARL SEMQ (sample 117) microanalysers. The instruments were operated at an accelerating voltage of 20 kV, a probe current of 125 μA , a sample current on Cu_2S standard of 11.0 nA, counting time 100/sec. The following standards and spectral lines were used: $\text{SK}_\alpha(\text{Cu}_2\text{S})$, MnK_α , FeK_α , $\text{CuK}_\alpha(\text{Cu}_2\text{S})$. Corrections were made to allow for absorption (Philibert, 1965), FeK_α fluorescence produced by CuK_α (Reed, 1965), and for atomic number difference (Philibert, Tixier, 1968). X-ray investigations were made with powder method using Fe-filtered CoK_α radiation.

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MODE OF OCCURRENCE

In the Lubin mine anilite occurs mainly in its western part, over an area of about 3 km². Sometimes it is the principal copper mineral, yet more commonly it accompanies djurleite as a subordinate component. In this case, it forms elongate lamellae 8 × 160 μm in size, averaging 4 × 100 μm (Phot. 1), and of polishing hardness one class lower than djurleite. Owing to this property, it is readily discernible both in reflected light and in scanning pictures in reflected electrons (Phot. 1). Compared with djurleite it is distinctly blue-grey, and its reflectance is lower by ~ 5%.

The other form of anilite occurrence is its presence in secondary calcite nests in the boundary dolomite. The calcite in question shows dark-grey internal reflections. In this case, anilite is generally the only Cu mineral. Exceptionally a single chalcocite grain may be present, but then it never has a direct contact with anilite. Occasionally anilite is accompanied by Cu₆FeS₅? (up to 20 vol.%), a mineral exhibiting the same morphological features as anilite, and whose colour and reflectance are similar to those of bornite. The discussed form of anilite occurrence is represented by automorphic columnar crystals (Phot. 2) of a size 24–120 μm, on the average 8 × 80–4 × 40 μm.

Some anilite grains show distinct cleavage, frequently obliterated during polishing. This feature is inconsistent with the description of anilite from Japan, in which cleavage failed to be noted although the crystals showed parting (Morimoto *et al.*, 1969). The reflectance of anilite with respect to chalcocite is 20%, and its colour compared with chalcocite is the same as of digenite.

In the area where anilite is an ore mineral, in secondary calcite nests in the boundary dolomite, up to 20–30 vol. % of gypsum and anhydrite was noted in carbonate rocks and shale, and β-boracite was recorded in sandstone. This indicates explicitly that the high salinity (alcalinity?) of the environment should preclude (or severely limit) the formation of chalcocite or djurleite and favour the rise of anilite. This hypothesis is further substantiated by the fact that the bornite-like mineral Cu₆FeS₅ has the morphology, and presumably the structure, of anilite.

CHEMICAL COMPOSITION

The chemical composition of anilite is given in Table 1. Sample 65 represents the first paragenesis of anilite forming lamellae in djurleite (Phot. 1). The microscopic features qualify the lamellae as typical anilite. Considering the chemical composition, they correspond to anilite with an admixture of djurleite. Such mode of occurrence is typical of the two minerals which commonly form twin or epitactic intergrowths (Morimoto *et al.*, 1969). Deviations from the formula Cu₇S₄ (Tab. 1, sample 65) could also be due to the small thickness of lamellae, which affects the resolution of the electron beam in width and depth. Moreover, anilite is softer than djurleite by one polishing hardness class, and consequently the lamellae have a concave surface, which changes the measuring geometry, specifically for a Cameca MS-46 microprobe with the angle $\nu = 18^\circ$. The mineral defined as djurleite is in fact djurleite with an admixture of anilite (Table 1, sample 65).

Automorphic anilite making up the other paragenesis (Phot. 2) is a mineral phase corresponding precisely to the formula Cu₇S₄ (Table 1, sample 117). It contains up to 0.27 wt. % of Fe as an admixture, in which it differs from anilite from Japan (Morimoto *et al.*, 1969). Chalcocite accompanies anilite only exceptionally (Table 1, no. 117/6), never forming intergrowths with anilite.

Table 1
Chemical composition of anilite and associated djurleite and chalcocite from Lubin copper mine

No	Weight %				Atomic proportions			Name
	S	Fe	Cu		Cu	Fe	S	
65/C1	22.00	≤0.08	78.63	100.63	7.21		4.00	Anilite
65/C2	21.18	≤0.08	78.77	99.95	1.88		1.00	Djurleite
65/C3	21.50	≤0.08	78.00	99.50	7.32		4.00	Anilite
65/D1	24.17	≤0.08	76.73	100.90	6.41		4.00	Anilite
65/D2	21.40	≤0.08	78.92	100.32	1.86		1.00	Djurleite
65/D3	24.96	≤0.08	75.25	100.21	6.09		4.00	Anilite
117/1	22.19	0.06	76.75	99.00	6.98	0.01	4.00	Anilite
117/2	22.93	0.06	77.04	100.03	6.78	0.01	4.00	Anilite
117/3	22.23	0.08	77.99	100.30	7.04	0.01	4.00	Anilite
117/4	21.79	0.14	76.98	98.91	7.13	0.01	4.00	Anilite
117/5	21.60	0.27	77.09	98.96	7.20	0.03	4.00	Anilite
117/6	20.04	≤0.02	80.44	100.48	2.02		1.00	Chalcocite
Teoret	22.38		77.62		7.00		4.00	Anilite
Teoret	20.48		79.52		1.96		1.00	Djurleite
Teoret	20.15		79.85		2.00		1.00	Chalcocite

≤ - limit of microprobe detection.

Mn content in anilite is less than 0.07 wt.% in both analysed samples.

Within the limits of measuring accuracy, the anilite under study is identical with its prototype:

$$a = 7.89 \pm 0.016, \quad b = 7.84 \pm 0.016, \quad c = 11.01 \pm 0.022$$

(Morimoto *et al.*, 1969);

$$a = 7.90 \pm 0.02, \quad b = 7.82 \pm 0.02, \quad c = 11.00 \pm 0.02$$

(Lubin mine).

Also the X-ray diffraction pattern of anilite from the Lubin mine shows perfect agreement with the diffractogram of the mineral phase with the given parameters which crystallizes in Pnma (Table 2, Koto, Morimoto, 1970). Some slight deviations in the intensity of reflections can be attributed to the admixture of Cu₆FeS₅, which is presumably isostructural with anilite.

Table 2

Pattern calculated for the orthorhombic Pnma with $a = 7.89$, $b = 7.84$, $c = 11.01$ (Koto, Morimoto, 1970) compared with anilite from Lubin Mine, Lower Silesia, Poland (Co K α , Fe filter)

Koto, Morimoto, 1970			Anilite from Lubin Mine		
<i>l</i>	<i>d</i>	<i>hkl</i>	<i>l</i>	<i>d</i> _{meas.}	<i>d</i> _{calc.}
11	6.413	101, 011			
4	3.945	200			
15	3.912	112			
56	3.356	211	6	3.35	3.36
57	3.345	121			3.34
42	3.328	103, 013	4	3.32	3.32
		202	4	3.19	3.21
40	3.207	022			3.19
3	3.063	113			
56	2.781	220	5	2.77	2.78
22	2.752	004	3	2.76	2.75
40	2.696	221			
34	2.687	203	3	2.67	2.69
27	2.599	104	2	2.59	2.60
54	2.543	031, 213			
53	2.537	123	3	2.50	2.53
8	2.432	311			
6	2.420	131			
20	2.375	302	2	2.39	2.38
5	2.262	132	2	2.25	2.26
17	2.216	223	3	2.20	2.21
8	2.179	230			
43	2.166	124	4	2.17	2.16
19	2.142	321			
19	2.137	231			
23	2.129	033	2	2.13	2.13
18	2.121	105, 015			
10	2.062	313			
23	2.055	133	2	2.06	2.05
14	2.047	115			2.05
20	1.9725	400	3	2.01	1.975
100	1.9562	224, 040	10	1.955	1.955
19	1.9416	401	3	1.931	1.944
5	1.9227	205			1.922
3	1.9129	410			
13	1.9015	304			
4	1.8846	411			
9	1.8768	323			
		215	2	1.863	1.866
8	1.8674	125			1.863
7	1.8479	314, 042			
6	1.8428	134			
2	1.8069	412	3	1.809	1.809
9	1.7979	142	3	1.791	1.794

const. tab. 2

Koto, Morimoto, 1970			Anilite from Lubin Mine		
<i>l</i>	<i>d</i>	<i>hkl</i>	<i>l</i>	<i>d</i> _{meas.}	<i>d</i> _{calc.}
6	1.7873	106			
4	1.7553	240, 420			
7	1.7374	403			
5	1.7334	241	1	1.719	1.730
4	1.6963	413			1.697
6	1.6888	143, 305	2	1.690	1.687
5	1.6839	035			
13	1.6781	422	4	1.675	1.679
16	1.6723	242			
11	1.6619	026, 206			
7	1.6547	333			
3	1.6505	315			
3	1.6468	135			
2	1.6276	216, 126			
2	1.5884	423			
2	1.5835	243			
2	1.5744	430			
2	1.5708	414	1	1.570	1.571

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Henryk KUCHA

ANILIT, Cu₃S₄, Z KOPALNI LUBIN Z DOLNEGO ŚLĄSKA W POLSCE

Streszczenie

Anilit z kopalni Lubin ma w granicach dokładności pomiaru identyczne parametry sieciowe jak anilit z kopalni Ani. Wynoszą one $a = 7.90 \pm 0.02$, $b = 7.82 \pm 0.02$ oraz $c = 11.00 \pm 0.02$. Również skład chemiczny jest podobny i odpowiada formule

Cu_7S_4 , różnica polega jedynie na niewielkiej domieszce Fe sięgającej 0,27% wag. Anilit z kopalni Lubin występuje głównie w dolomicie granicznym w dwu paragenezach: w postaci lamell w djurleicie bądź samodzielnie w postaci wydłużonych słupków obecnych w gniazdach wtórnych węglanów. W tym ostatnim przypadku często towarzyszy mu identyczny pod względem cech morfologicznych $\text{Cu}_6\text{FeS}_5(?)$, optycznie zbliżony do bornitu.

OBJAŚNIENIA FOTOGRAFII

Fot. 1. Zorientowane zrosty djurleitu z lamellami anilitowymi. Dolomit graniczny, preparat 65/D
a – obraz skanningowy w elektronach odbitych, *b* – obraz skanningowy Cu K_α , *c* – obraz skanningowy S K_α . Wielkość obrazu $200 \times 210 \mu\text{m}$.

Fot. 2. Automorficzne kryształy anilitu występujące w gniazdach wtórnego kalcytu w dolomicie granicznym. Dolomit graniczny, preparat C-4, światło odbite

Хенрик КУХА

АНИЛИТ, Cu_7S_4 , ИЗ ШАХТЫ ЛЮБИН В НИЖНЕЙ СИЛЕЗИИ, ПОЛЬША

Резюме

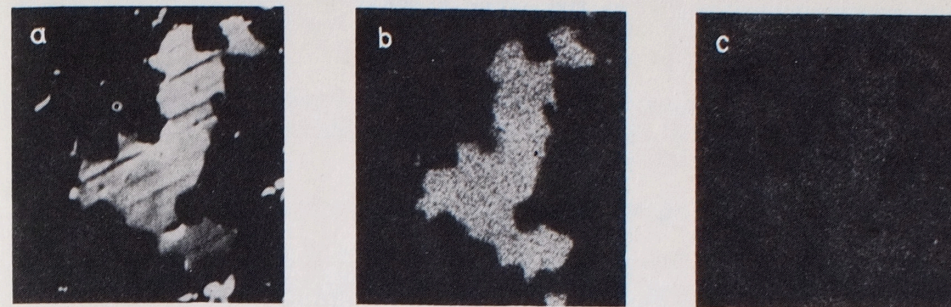
Анилит из шахты Любин в пределах точности измерения имеет параметры кристаллической решетки идентичные анилиту из шахты Ани. Они составляют $a = 7,90 \pm 0,02$, $b = 7,82 \pm 0,02$ и $c = 11,00 \pm 0,02 \text{ \AA}$. Химический состав также подобен и соответствует формуле Cu_7S_4 , разница заключается лишь в небольшой примеси Fe входящей до 0,27% веса. Анилит из шахты Любин выступает главным образом в граничном доломите в двух парagenезисах: в форме lamell в djurleite либо самостоятельно в форме вытянутых столбиков, присутствующих в гнездах вторичных карбонатов. В последнем случае его часто сопровождает идентичный в отношении морфологических признаков $\text{Cu}_6\text{FeS}_5(?)$, похожий по внешнему виду на борнит.

ОБЪЯСНЕНИЕ ФОТОГРАФИЙ

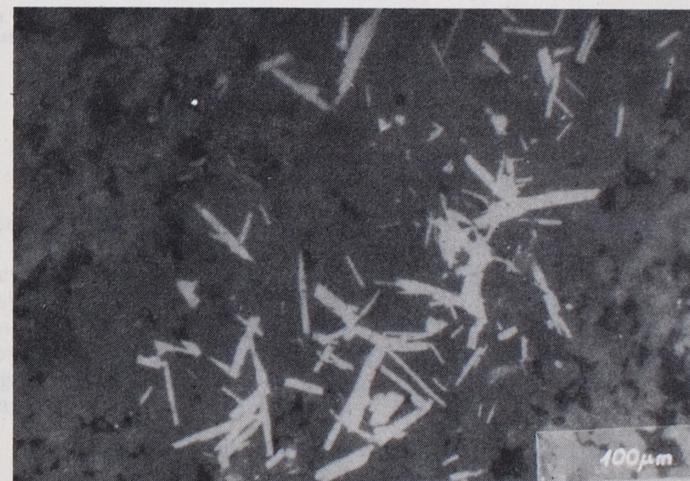
Фот. 1. Ориентированные сростки djurleita с lamellami анилита. Граничный доломит, образец 65/D

a – вид в сканиговом электронном микроскопе, *b* – вид в сканиговом электронном микроскопе Cu K_α , *c* – вид в сканиговом электронном микроскопе S K_α . Величина поля $200 \times 210 \mu\text{m}$

Фот. 2. Автоморфные кристаллы анилита выступающие в гнездах вторичного кальцита в граничном доломите, образец C-4, отраженный свет



Phot. 1. Oriented intergrowth of djurleite with lamellae of anilite. Boundary dolomite, sample 65/D
a – scanning picture in reflected electrons, *b* – X-ray scanning picture of Cu K_α , *c* – X-ray scanning picture of S K_α .
 The size of pictures $200 \times 210 \mu\text{m}$



Phot. 2. Automorphic crystals of anilite in the nests of secondary calcite in boundary dolomite. Boundary dolomite, sample C-4, reflected light

Henryk KUCHA – Anilite, Cu_7S_4 , from Lubin Mine, Lower Silesia, Poland