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# MYRMEKITIC STRUCTURES OF HAEMATITE IN BORNITE AND THEIR GENESIS /ZECHSTEIN COPPER DEPOSITS, POLAND/

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A b s t r a c t. Myrmekitic structures $Cu_5FeS_4$ + $Fe_2O_3$ occur in the top part of Weissliegendes sediments in the paragenesis selenite - haematite - silver amalgams. The structures formed at Eh ca.-0.2 and pH ca. 8.5, with total dissolved sulphur amounting to $10^{-1}$ M. These conditions gave rise to epigenetic silver amalgams and secondary iron patches /$Fe^{3+}$/. The value of pH suggests that this mineralization has been associated with brine solutions.

## INTRODUCTION

Zechstein copper deposits contain myrmekitic intergrowth: chalcocite + bornite, bornite + chalcocite and bornite + galena. The latter formed at pH~8.5 /Kucha, Salamon 1975/, suggesting their association with brine solutions. All these myrmekitic structures arose at low temperatures with simultaneous crystallization of the two intergrowing minerals.

Myrmekitic structures bornite + haematite were described by Ramdohr /1975/ and interpreted as the process of hypogene oxidation.

## EXPERIMENTAL

### M i c r o s c o p i c  s t u d i e s

The myrmekitic structures bornite + haematite adjoin the nearly horizontal selenite veinlets with silver amalgams and haematite in the

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top part of the Weissliegendes. Fine, flat haematite grains are, as a rule, randomly distributed /phot. 1, 2/, but sometimes larger $Fe_2O_3$ lamellae show parallel orientation to the 111 plane of bornite /phot. 2/.

Macroscopically the veinlets in question and their surroundings are brown-reddish in colour, giving the rock the characteristic stamp of secondary "iron patches".

## Chemical analysis

Chemical investigations were carried out with a Cameca MS-46 microprobe operated at an accelerating voltage of 20 kV and a probe current of 150 μA. The following standards, compounds and spectral lines were used: $OK\alpha/Fe_2O_3/$, $SK\alpha/Cu_5FeS_4/$, $TiK\alpha$, $MnK\alpha$, $FeK\alpha/Fe_2O_3$, $Cu_5FeS_4/$ and $ZnK\alpha$. Corections were made for radiation absorption /Philibert 1956/, fluorescence /Reed 1965/ and atomic number difference /Philibert, Tixier 1968/.

The bornite studied /Table 1/ has somewhat decreased Cu and increased Fe contents, which seems to be due to the submicroscopic myrmekitic structures of haematite in bornite.

The chemical composition of haematite varies from $Fe_2O_3$ to $\beta\ Fe_2O_3 \cdot H_2O$ /Table 1/. It frequently contains up to 1.3% Cu. Copper is usually accompanied by sulphur /Table 1/. The Cu : S atomic proportion suggests that it may be the myrmekites $Fe_2O_3 + Cu_5FeS_4$ and $Fe_2O_3 + Cu_2S$.

Table 1

Chemical composition of bornite /B/ and haematite /H/ forming myrmekitic intergrowths /wt. %/

| No | Mineral | O | S | Ti | Fe | Cu | ∑ | Cu : S |
|---|---|---|---|---|---|---|---|---|
| 66/A1 | H+B | 41.0 | ⩽ 0.08 | 0.99 | 54.56 | 1.30 | 97.75 | |
| 66/A2 | H+B | 36.0 | 2.21 | ⩽0.07 | 57.58 | 2.89 | 98.68 | 0.66 |
| 66/A3 | H | 38.0 | ⩽ 0.08 | " | 60.23 | 0.82 | 99.05 | |
| 66/B2 | H | 30.0 | " | " | 69.50 | ⩽ 0.13 | 99.50 | |
| 66/C2 | H+B | 31.0 | 0.24 | " | 68.21 | 0.99 | 100.44 | 2.08 |
| 66/D2 | H+B | 36.5 | 1.69 | " | 55.34 | 5.98 | 99.51 | 1.79 |
| 66/D3 | H+B | 39.5 | 1.23 | " | 56.04 | 2.02 | 98.79 | 0.83 |
| 66/C3 | B | - | 25.68 | " | 12.79 | 60.71 | 99.18 | 1.19 |
| 66/D1 | B | - | 25.40 | " | 12.66 | 61.74 | 99.80 | 1.23 |
| $\beta Fe_2O_3 \cdot H_2O$ theoret. | | 35.14 | | | 62.85 | | | |

Sought for but not detected: Mn ⩽ 0.06, Zn ⩽ 0.06.



## CONCLUSIONS

The principal type of the myrmekitic structures discussed is bornite + haematite /phot. 1, 2/. An analysis of the stability of the Cu-Fe-S-O-H system /Garrels, Christ 1965/ indicates thet these structures formed in the stability field $Cu_5FeS_4 + Fe_2O_3$ limited by the Eh -0.1 to -0.3 and the pH 6.5 - 10.5. The total sulphur dissolved was probably $10^{-1}$ M because the field in question disappears for lower values.

According to Ramdohr /1975/, the discussed structure $Cu_5FeS_4 + Fe_2O_3$ arose as a result of the "simultaneous formation of myrmekitic intergrowths in an independent process".

The average value of pH = 8.5 for the formation of the myrmekites bornite + haematite /as well as the one determined for the myrmekite bornite + galena, Kucha and Salamon 1975/ suggests that both the myrmekite in question and the secondary "iron patches" may owe their origin to brine solutions.

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## STRUKTURY MYRMEKITOWE HEMATYTU W BORNICIE I ICH INTERPRETACJA GENETYCZNA /CECHSZTYŃSKIE ZŁOŻA RUD MIEDZI, POLSKA/

### Streszczenie

Struktury myrmekitowe $Cu_5FeS_4 + Fe_2O_3$ występują w stropowej części utworów białego spągowca w paragenezie selenit-hematyt-amalgamaty srebra. Struktury te tworzyły się w warunkach: Eh ca-0,2, pH ca 8,5, suma

rozpuszczonej siarki ca $10^{-1}$ M. W tych warunkach powstały epigenetyczne amalgamaty srebra i wtórne plamy żelaza /$Fe^{3+}$/. Wartość pH sugeruje powiązanie tej mineralizacji z roztworami solankowymi.

OBJAŚNIENIA FOTOGRAFII

Fot. 1. Robakowate, bezładnie rozmieszczone wrostki hematytu w bornicie, tworzące strukturę myrmekitową. Kopalnia Lubin, preparat MAR 66. Światło odbite, imersja.

Fot. 2. Lamelle hematytu rozmieszczone bezładnie oraz zorientowane zgodnie z płaszczyzną /111/ bornitu. Kopalnia Lubin, preparat MAR 60. Światło odbite, imersja.

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МИРМЕКИТОВЫЕ СТРУКТУРЫ ГЕМАТИТА В БОРНИТЕ И ИХ ГЕНЕТИЧЕСКАЯ ИНТЕРПРЕТАЦИЯ /ЦЕХШТЕЙНОВЫЕ МЕДНЫЕ МЕСТОРОЖДЕНИЯ, ПОЛЬША/

Р е з ю м е

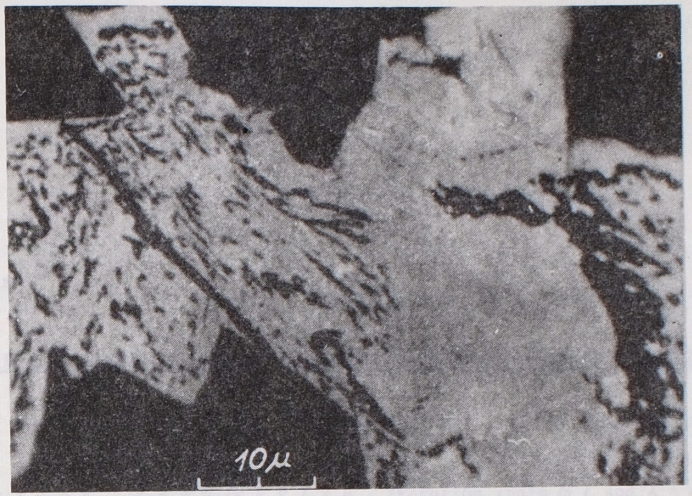
Мирмекитовые структуры $Cu_5FeS_4$ + $Fe_2O_3$ встречаются в кровельной части образований белого лежня в парагенезе: селенит-гематит-амальгамы серебра. Эти структуры образовались в условиях: Eh около 0,2, pH около 8,5, сумма растворимой серы около $10^{-1}$ M. В этих условиях образовались эпигенетические амальгамы серебра и вторичные пятна железа /$Fe^{3+}$/. Величина pH намечает на связь этой минерализации с соляными растворами.

ОБЪЯСНЕНИЯ К ФОТОГРАФИЯМ

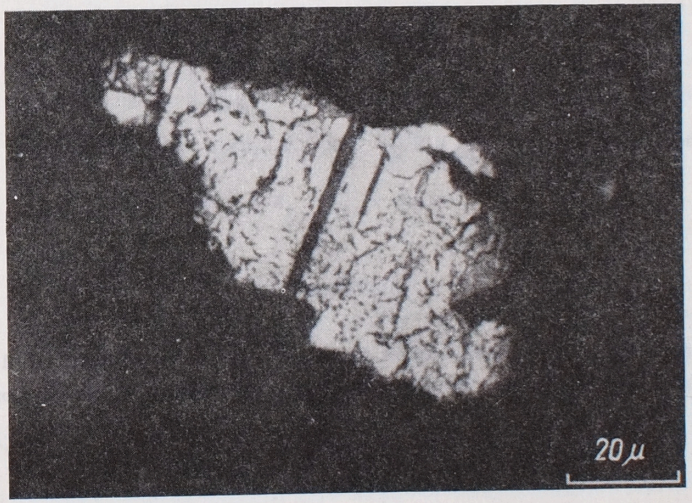
Фото 1. Образующие мирмекитовую структуру, неупорядоченные вростки гематита в борните. Рудник Любин, образец MAR 66. Отраженный свет, иммерсия.

Фото 2. Неупорядоченные, а также ориентированные в плоскости /111/ борнита, пластинки гематита. Рулник Любин, образец MAR 60. Отраженный свет, иммерсия.






Phot. 1. Vermiform, randomly distributed inclusions of haematite in bornite, forming myrmekitic structure. Lubin mine, microprobe sample 66. Reflected light, immersion




Phot. 2. Haematite lamellae randomly distributed and oriented parallel to the /111/ plane of bornite. Lubin mine, microprobe sample 60. Reflected light, immersion

Henryk KUCHA - Myrmekitic structures of haematites in bornite and their genesis /Zechstein Copper Deposits, Poland/