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MINERALOGICAL CHARACTERISTICS AND ORIGIN OF SIDERITIC CONCRETIONS FROM THE „SZCZYGŁOWICE” COAL MINE, UPPER SILESIA

Abstract. Carbonate concretions, occurring in the Ruda and Orzesze Beds (Upper Carboniferous) in the Szczygłowiec coal mine, show diversified mineral composition and structure. Sideritic concretions, displaying granular structure, and siderite-dolomite ones showing either oölitic or fine-grained structures have been distinguished. Different character of concretions is supposed to be due to their origin in successive stages of early diagenetic processes under varying pH conditions and gradual lithification of parent sediments.

INTRODUCTION

During geological investigations in NW part of the Upper Silesian Coal Basin, numerous sideritic concretions were found to occur in rocks surrounding coal beds in the area of the „Szczygłowiec” mine. These concretions occur in all the stratigraphic horizons of productive Carboniferous deposits (Chodyniecka 1973), but are particularly abundant in the Ruda and Orzesze Beds. 39 samples have been collected from the following horizons of the Ruda Beds: 401/1, 401/2, 403/1, 404/4, 405/1, 405/3, 406/1, 406/3, 407 and 408/2. 29 samples collected from the tops and bottoms of the Orzesze Beds are coming from the following horizons: 348, 349, 350/1, 350/2, 351/2, 352/2, 352/3, 353, 354, 357/1, 358, 358/2, 360/1 and 364. The concretions occur there irregularly, mainly within claystones, only sporadically in mudstones. Generally they are small (several cm in diameter), only locally being up to several centimetres in size. Larger, elongated, lenticular forms are but sporadically observed. They are brownish-gray in colour and locally contain plant imprints.

EXPERIMENTAL AND RESULTS

Microscope examinations have shown that the concretions differ in structure. The majority of them (nearly 70%) consists of clayey carbonate matrix, the grain-size of which is below 0.01 mm (Phot. 1). This sideritic matrix is compact and brown in colour. Siderite grains are impregnated with clay minerals — kaolinite and

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illite. Some of the concretions are predominantly sideritic with subordinate amount of clay minerals but in numerous of them the content of siderite decreases down to 25%. Apart from clay minerals, there also occur quartz grains and organic matter. The concretions are often fractured and the fissures filled with coarse-grained calcite or, much less abundant, quartz.

Approximately 20 percent of samples examined displays granular structure. They consist of siderite crystals, 0.01–0.08 mm in size (Phot. 2), often rimmed with iron oxides. Siderite is accompanied by clay minerals and quartz, occurring in sharp-edged grains up to 0.1 mm in size. Coarse-crystalline quartz is filling fissures.

Table 1
Chemical composition of soluble parts of representative samples of sideritic concretions

Sample No.	1	2	3
Structure	granular	oölitic	fine-grained
Horizon	354 bottom	403/2 top	401/1 bottom
Fe ₂ O ₃	2.30	4.00	7.20
FeO	40.3	48.4	30.0
MgO	2.00	3.04	2.38
MnO	0.30	0.70	0.40
CaO	1.10	2.00	3.66
CO ₂	28.0	34.7	24.1
P ₂ O ₅	0.38	0.55	0.75

Oölitic concretions consist of oöide aggregates, 0.2–0.7 mm in size (Phot. 3). Individual oöides consist of a nucleus, usually represented by small quartz grain or coal fragment, and outer zone composed of siderite matrix. Oöides are brown in colour and oxidized on margins. The spaces between them are filled with fine-grained siderite, clay minerals and small amounts of coal. Some oöides are deformed — flattened or bent.

Table 2
Computed contents of carbonates in soluble parts of concretions analyzed (a) and recalculated into 100 per cent (b)

Sample No.	1		2		3	
	a	b	a	b	a	b
FeCO ₃	64.9	90.0	78.0	87.8	48.5	80.1
MgCO ₃	4.1	5.7	6.4	7.1	4.9	8.2
MnCO ₃	0.5	0.7	1.1	1.3	0.7	1.1
CaCO ₃	2.0	2.7	3.3	3.8	6.4	10.6
Total	71.5	99.1	88.8	100.0	60.5	100.0

Representative samples of all these structural varieties have been selected for chemical, X-ray, thermal and infrared spectroscopic studies.

Chemical analyses have been carried out using classical procedure after dissolving the samples in hot (1:10) HCl. Ferrous oxide has been determined by means of Jacob's method after decomposition in water vapour atmosphere. MnO, P₂O₅, Fe₂O₃ and CO₂ were estimated in separately dissolved portions. The results are presented in Tab. 1. As follows from these data, all the three types of concretions abound in FeO, accompanied by subordinate amounts of MgO, CaO and MnO. Calculated carbonate content in analysed samples (Tab. 2a) varies from 60 to nearly 89%, whereby the poorest in them are fine-grained ones. Recalculation of carbonate component into 100% clearly shows the difference of chemical composition in individual types of concretions (Tab. 2b). Fine-grained concretions contain more CaCO₃ whilst the percentual contents of FeCO₃ and MgCO₃ in all the types distinguished are similar. These concretions are also relatively enriched in phosphorus what can be explained by higher content of terrigenous admixture.

Thermal analyses have been carried out using Hungarian MOM type Q Derivatograph. The samples weighing 600 mg were heated to 1000°C with the rate 10°/min. The obtained curves (Fig. 1) clearly indicate that the main crystalline phase of the concretions is siderite. Its thermal decomposition takes place in the range 460–540°C and is followed by exothermal oxidation reaction of ferrous oxide thus formed into magnetite. The liberation of CO₂ is manifested by considerable loss of weight, marked on TG curves. When examining the curve obtained for representative oölitic sample (no. 2), we observe two additional endothermal effects at 750 and 850°C, characteristic of dolomite. They are accompanied by loss of weight, marked on TG curve.

X-ray studies have been carried out by means of Siemens diffractometer using Ni-filtered CoK α radiation (Fig. 2). Quartz powder was used as standard. X-ray diffractograms have confirmed that siderite is the major carbonate phase of the concretions, though the value of most characteristic reflection was 2.80 Å. Such increased d_{hkl} value of reflection, when compared with the standard one for pure siderite (2.785–2.790 Å, after Mikheiev 1967) is considered to be due to isomorphic substitution of Ca for Fe. Similar data were reported by Ratajczak (1969) for sideritic concretions from Westphalian deposits of the Lublin Coal Basin, but in that case the change of d_{hkl} value was due to Mg substitution for Fe. In our concretions, the admixture of Mg is not manifested in X-ray patterns. Besides, no double reflections, reported by Zaricki (1965) for concretions from Donietsk Basin and resulted from the presence of two sideritic phases, were observed. Similar data on concretions from the Ostrava–Karvina Coal Basin, consisting of siderite, ferrous dolomite and calcite

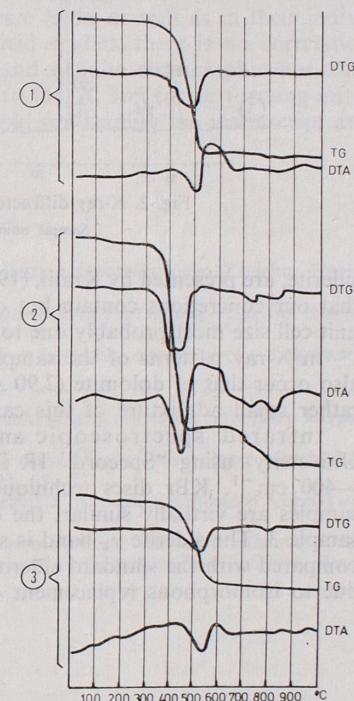


Fig. 1. DTA, TG and DTG curves of sideritic concretions

Sample numbers correspond to the table 1

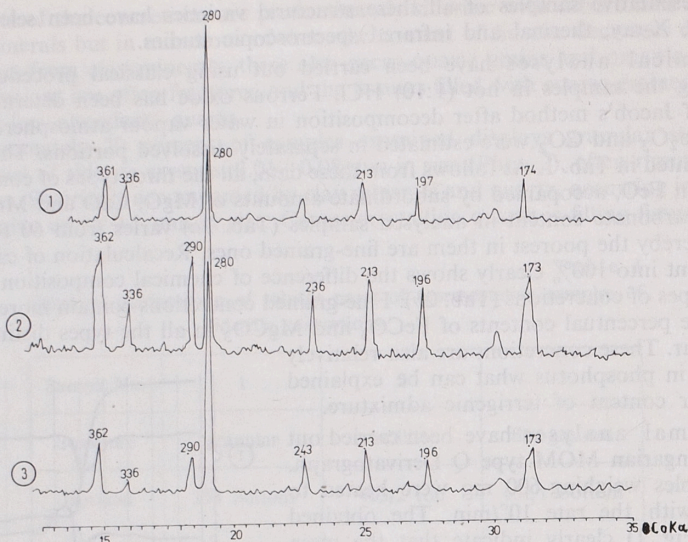


Fig. 2. X-ray diffractometer patterns of sideritic concretions
Sample numbers correspond to the table 1

siderite, are presented by Kralik (1970). On the basis of X-ray study we may conclude that our concretions contain but one sideritic phase showing some increase of the unit cell size most probably due to isomorphous substitution of Ca for Fe.

In X-ray patterns of the samples 2 and 3, apart from siderite reflections there also occur that of dolomite (2.90 Å). Very low intensity of this reflection is due to rather small admixture of this carbonate.

Infrared spectroscopic analysis was carried out by Dr. A. Jon (Silesian University) using "Specord" IR instrument in the wave-number range of 4000—400 cm^{-1} . KBr discs technique was applied. Absorption spectra of analyzed samples are virtually similar, the quartz admixture being most pronounced in the sample 3. The siderite ν_4 band is slightly shifted towards smaller wave-numbers as compared with the standard siderite spectrum (737 cm^{-1} , Moenke 1962). It may be due to isomorphous replacement of Fe^{2+} by Ca^{2+} .

DISCUSSION

Distinct diversity of structure and of mineral composition of the concretions examined suggest that they were formed during several stages of diagenesis of parent sediments. Detailed studies of Narebski (1957, 1974) on carbonate concretions of the Carpathian Flysch and of the Żytawa Basin have shown them to be formed during early diagenesis of inhomogeneous pelitic sediments, whereby their mineral and chemical composition depends on geochemical character of the environment. It is supposed that the change of chemical composition and of acidity (pH) of pore solutions was also responsible for variation of mineral composition of the concretions from the Ruda and Orzesze Beds, whilst gradual lithification and sedimentation conditions of parent sediments were the cause of their different structures. In the present authors' opinion, coarse-grained sideritic concretions were formed in

water-rich, poorly cemented sediment and precipitated from slightly acid solutions. Under these conditions fairly large siderite crystals could precipitate while accompanying Ca and Mg ions did not form separate phases but enter into siderite lattice.

Concretions showing oolitic structure are supposed to be formed later from more alkalized solutions but, probably, at lower Eh, since these conditions are favouring precipitation of Ca and Mg as dolomite phase (Narebski 1957), which was found to be present as admixture in the concretions analyzed. The available data indicate that the most abundant fine-grained concretions must have been formed during later stage of diagenetic processes in partly cemented (lithified) sediment. This opinion is supported by much higher admixture of clay and other terrigenous material in these concretions. It is supposed that the force of crystallization of growing fine carbonate grains was not sufficient to displace the particles of partly cemented sediments which, consequently, remained within these concretions. Finally, it should be emphasized that physicochemical conditions of diagenetic processes and their evolution both in the Ruda and Orzesze Beds, as well as in their individual horizons, were similar. As follows from field studies, there is no correlation between the type of concretions distinguished and definite stratigraphic horizons.

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CHARAKTERYSTYKA MINERALOGICZNA I GENEZA KONKREJCJI SYDERYTOWYCH Z KOPALNI WĘGLA „SZCZYGLÓWICE”, GÓRNY ŚLĄSK

Streszczenie

Konkrekcje występujące w kopalni Szczygłowie w warstwach rudzkich i orzeskich mają zróżnicowaną strukturę i skład mineralny. Badania chemiczne, mikroskopowe, rentgenograficzne i analiza spektroskopowa w podczerwieni wykazały, że występu-

яący в конкрециях сидерит zawiera izomorficzne podstawienia wapnia i magnezu. Konkrecje o strukturze ziarnistej mają skład сидеритовый, а в конкрециях о структуре оолитовой і микрозиарнистеj obok сидериту występuje również dolomit.

Zróznicowana struktura і skład mineralny конкреции związane są z ich genezą. Tworzyły się one w różnych stadiach diagenety. Jako pierwsze powstały конкреции сидеритовые, а następnie przy zmienionym, wyższym pH roztworów ilowych — конкреции сидеритово-доломитовые о структуре оолитовой. Produktem ostatniego stadium diagenety w częściowo zlitfikowanym osadzie są сидеритово-доломитовые конкреции о структуре микрозиарнистеj.

OBJAŚNIENIA FIGUR

Fig. 1. Krzywe termiczne różnicowe конкреции сидеритовых
Fig. 2. Dyfraktoqramy rentgenowskie конкреции сидеритовых

OBJAŚNIENIE FOTOGRAFII

Fot. 1. Konkrecja сидеритова о структуре микрозиарнистеj
Nikole X. Pow. 120×
Fot. 2. Konkrecja сидеритова о структуре ziarnistej
Nikole X. Pow. 120×
Fot. 3. Konkrecja сидеритова о будowie оолитowej
Nikole X. Pow. 120

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МИНЕРАЛОГИЧЕСКАЯ ХАРАКТЕРИСТИКА И ГЕНЕЗИС СИДЕРИТОВЫХ КОНКРЕЦИЙ ИЗ КАМЕННОУГОЛЬНОЙ ШАХТЫ «ЩИГЛОВИЦЕ», ВЕРХНЯЯ СИЛЕЗИЯ

Резюме

Конкреции, присутствующие в шахте «Щигловице» в рудских и ожеских слоях, имеют разнородную структуру и минеральный состав. Химические, микроскопические, рентгенографические и ИК-спектроскопические исследования обнаружили, что присутствующий в конкрециях сидерит изоморфически замещен кальцием и магнием. Конкреции зернистой структуры сидеритового состава, а в конкрециях оолитовой и микрозернистой структуры кроме сидерита присутствует также доломит.

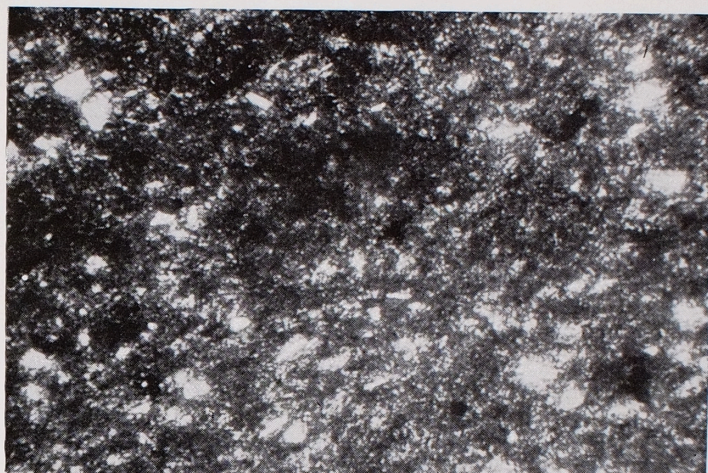
Дифференцированные структура и минеральный состав конкреций связаны с их генезисом. Они образовались в различных стадиях диагенеза. В качестве первых образовались сидеритовые конкреции, а затем при измененном, высшем pH илистых растворов образовались сидерит-доломитовые конкреции оолитовой структуры. Продуктом последней стадии диагенеза в частично литифицированном осадке являются сидерит-доломитовые конкреции микрозернистой структуры.

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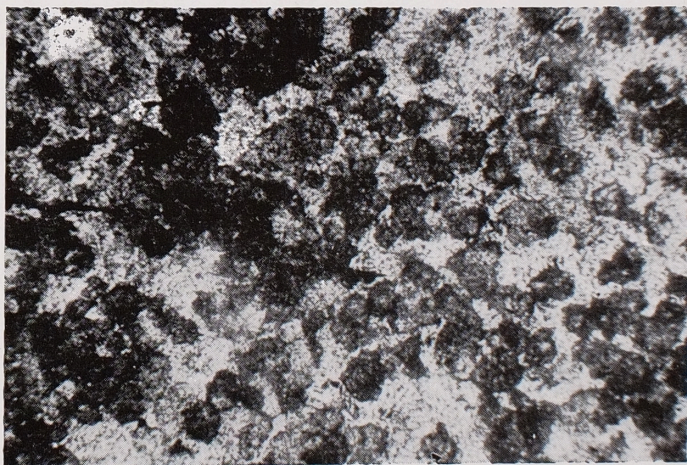
Фиг. 1. Кривые ДТА сидеритовых конкреций
Фиг. 2. Рентгеновские дифрактограммы сидеритовых конкреций

ОБЪЯСНЕНИЯ К ФОТОГРАФИЯМ

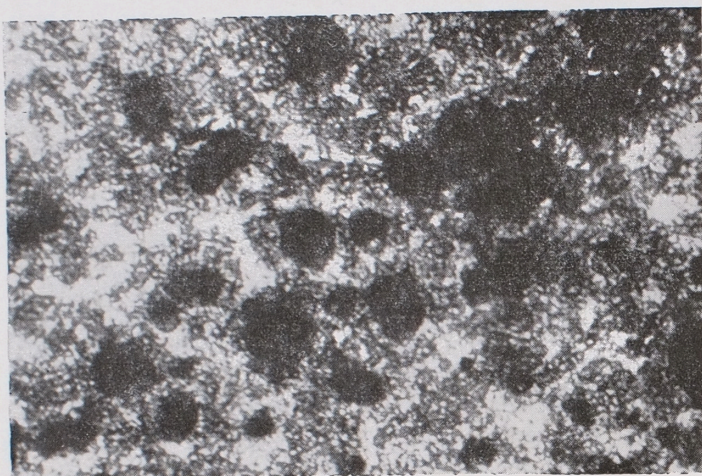
Фото 1. Сидеритовая конкреция микрозернистой структуры
Скрещенные николи, увел. ×120
Фото 2. Сидеритовая конкреция зернистой структуры
Скрещенные николи, увел. ×120
Фото 3. Сидеритовая конкреция оолитового строения
Скрещенные николи, увел. ×120



Phot. 1. Fine-grained structure of sideritic concretion
Crossed nicols, 120 \times (Phot. Z. Golasowski)



Phot. 2. Granular structure of sideritic concretion
Crossed nicols, 120 \times (Phot. Z. Golasowski)



Phot. 3. Oölitic structure of sideritic concretion
Crossed nicols, 120 \times (Phot. Z. Golasowski)