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## Problems of modelling of Zn-Pb ores of the Mississippi Valley-type in the sediments of the Younger Paleozoic

Two hypothetical models of the ore bodies in the carbonate sediments of the Younger Paleozoic have been presented. The first model, characteristic for the western part of the NE margin of the Upper Silesian Coal Basin, corresponds to the ore bodies related to the pre-Triassic paleorelief. In the second one — the ore bodies display a distinct vertical scatter with no relation to the pre-Triassic paleorelief. This model is characteristic for the eastern part of the area discussed. Differentiation in the models can result from the different stages of the karst system development. The karst systems, being the mineralization traps, determine the primary form of the ore bodies.

### INTRODUCTION

Search for the Zn-Pb mineralization of the MVT in the Triassic sediments done since several decades in the north-eastern margin of the Upper Silesian Coal Basin has proved an existence of the similar type of mineralization in the Devonian and Carboniferous rocks as well as in the Permian conglomerates.

The showings of mineralization found in the Younger Paleozoic rocks have been an object of detailed research since 1962. Due to this research the Zn-Pb mineralization has been discovered in the different areas and of different intensity. In general — the mineralization was more or less spatially connected with that in the Triassic sediments. There exists, however, a distinct difference due to which the later studies caused a decrease in the primary optimism. It appeared, namely, that the mineralization in the Younger Paleozoic being in the ore mineralogy identical with that in the Triassic, differs in the form of the ore bodies. We have, therefore, registered several areas of different size which display the occurrence of the mineralization in the

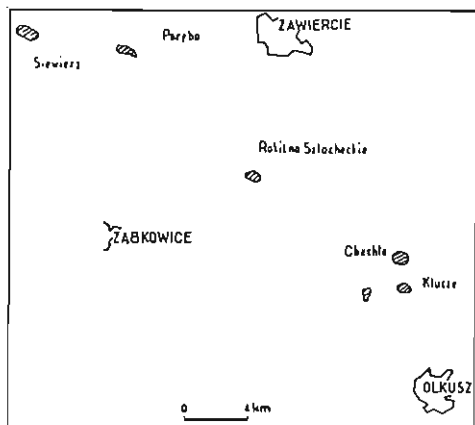


Fig. 1. Szkic lokalizacji  
Sketch of location

Younger Paleozoic, but we are far from constructing a model (models) of that mineralization. The problem concerns mainly the geometric model. It is, therefore, difficult to answer the main question whether the mineralization forms concentrations of industrial significance.

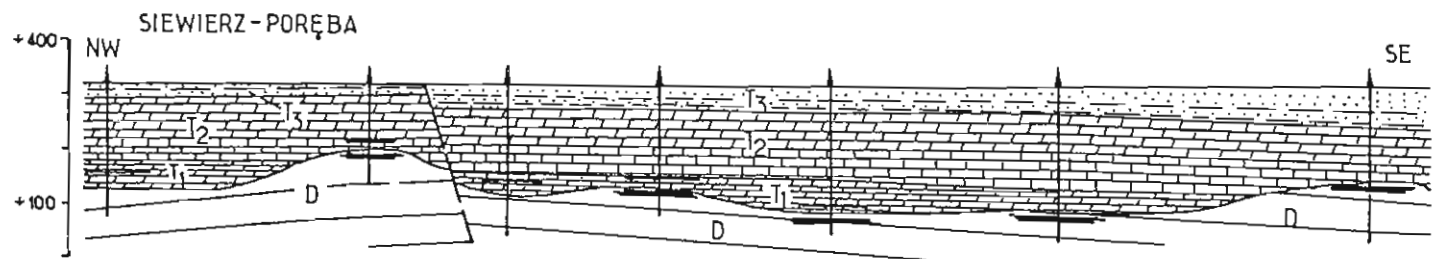
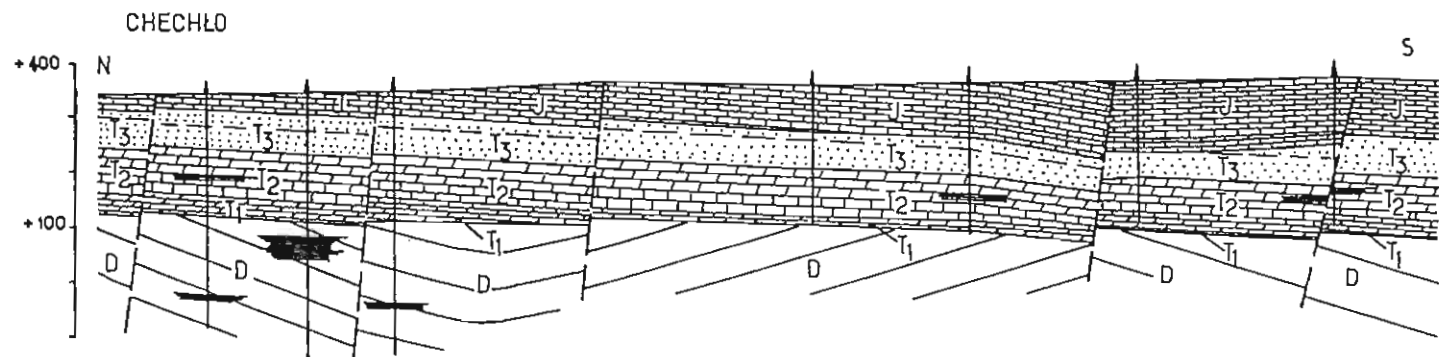
The present paper represents an attempt to construct models of Zn-Pb mineralization in the Paleozoic rocks with a discussion on difficulties connected with that trial.

Numerous papers on Zn-Pb mineralization in the Younger Paleozoic rocks can be quoted as references. E. Górecka (1978) treats the showings of mineralization in the Paleozoic as the root zones for the mineralization in the Triassic and she connects them with the hydrothermal solutions. J. Gładysz and S. Śliwiński (1979) concern the relation between the mineralization discussed in the Siewierz region and the fault, as the channel leading mineralization solutions from the depth, as well as porosity of the carbonate rocks environment, in that — among others — with the karst. T. Galkiewicz and S. Śliwiński (1985) connect the Zn-Pb mineralization in the Triassic and in the Younger Paleozoic rocks with the ortho- or para-hydrothermal solutions and with the tectonic zones which have acted as the paths leading solutions from the deep magma sources. C. Harańczyk (1979) connects the Zn-Pb ores from the epi-Variscan cover with the re-opening in the Cimmerian-Alpine cycle of the old fissures for the basic-alkaline magma sources and with the repeated pulsating rise of the solutions. S. Kurek (1988) expresses an opinion on the occurrence of the mineralization as a result of the mixing between meteoric waters (mineralized brines) of the karst system with the marine waters, without hydrothermal water supply.

## GEOLOGICAL SETTING

Ore areas chosen to be characteristic lie in the north-eastern margin of the Upper Silesian Coal Basin. They form a zone of about 35 km in length and of general trend





Devonian (Emsian) followed by the shallow sea carbonate sediments of the Middle Upper Devonian. The Lower Carboniferous represent the carbonate and detritic marine deposits facially differentiated. The final part of the Variscan level corresponds to the paralic-limnic coal-bearing deposits of the Upper Carboniferous.

Weak deformations of the Variscan level are expressed by a presence of numerous folds of NWW-SSE directions, cut with the normal and reversed folds of the system of N 110-120° as well as with the normal faults of N 20-30°. The anticlinal structures, in the cores of which there occur the Middle Devonian sediments display a differentiated morphology of the pre-Triassic surface. All the mineralization showings in the Younger Paleozoic deposits lie in the areas of the differentiated palcorelief.

The Permian-Mesozoic-Cainozoic structural stage has been built of the Permian, Triassic, Jurassic, Tertiary and Quaternary deposits with some erosional and stratigraphic gaps (Fig. 3). Deformations due to the Alpine cycle are weak and expressed mainly by the blocking tectonics. In the carbonate Triassic deposits, mainly in the epigenetic dolomites of the Lower Muschelkalk, there occur zinc and lead concentrations. Fig. 2 presents a development of the area under description with gaps discordancies and on that back-ground — a position of the MVT mineralization in the Triassic and Younger Paleozoic.

#### SHORT CHARACTERISTICS OF THE MINERALIZATION IN THE YOUNGER PALBOZOIC SEDIMENTS

It should be stressed that the recognition of the Zn-Pb mineralization in the Younger Paleozoic sediments is much worse in comparison to that in the Triassic. In contrary to the mineralization in the Triassic which has been intensively exploited since some centuries the mineralization in the Paleozoic has been known only from the boreholes. Due to those fragmentary data we can, however, present a rough characteristic of this mineralization.

**S t r a t i g r a p h y :** Middle Devonian, rarely — Lower Carboniferous, exceptionally — Permian.

**S t r u c t u r e :** anticlinal zones built of the carbonate deposits; buried pre-Triassic relief; strata dips of 5-45°.

Fig. 3. Examples of occurrence of Zn-Pb mineralization in the Chechło and Siewierz — Poręba deposits; cross-section through the Siewierz — Poręba deposit along the elongation of the structure of the Paleozoic sediments

1 — limestones; 2, 4 — dolomites; 3 — mudstones, sandstones; 5 — boreholes; 6, 7 — ore bodies; 6 — in Devonian, 7 — in Triassic; J — Jurassic; T<sub>3</sub> — Upper Triassic; T<sub>2</sub> — Middle Triassic; T<sub>1</sub> — Lower Triassic; D — Devonian

Przykłady lokowania się mineralizacji Zn-Pb w złożach Chechło i Siewierz — Poręba; przekrój przez złożę Siewierz — Poręba po rozciągłości struktury utworów młodszego paleozoiku

1 — wapienie; 2, 4 — dolomity; 3 — mułowce, piaskowce; 5 — otwór wiertniczy; 6, 7 — ciała rudne; 6 — w dewonie, 7 — w triasie; J — jura; T<sub>3</sub> — trias górny; T<sub>2</sub> — trias środkowy; T<sub>1</sub> — trias dolny; D — dewon

Position of the mineralization intervals in relation to the pre-Triassic paleorelief: 0-100 m from the paleorelief's surface, sporadically till 200 m.

Lithology of the adjacent rocks: dolomites, dolomite breccias, rarely — limestones.

Forms of the ore bodies: ore minerals — sphalerite, wurztite, galena, iron sulfides; accompanying minerals — calcite, dolomite, rare — barite.

Ore macrostructures: blended breccia, crustified ores, dispersed ores.

Zn-Pb metal ratio: from 1:1 to 4:1.

#### AN ATTEMPT OF DETERMINATION OF THE MINERALIZATION MODEL IN THE YOUNGER PALEOZOIC SEDIMENTS

First discoveries of the mineralization under discussion, done in the 60-ies, were very optimistic due to the borehole of the ore bodies displaying a significant thickness and high metal content (e.g., the borehole S/17 in Siewierz or BB/15 in Chechło). A systematic search started resulting in a discovery of new ore fields in new areas. In that first stage of studies the geometric model of the ore bodies known from the Tertiary sediments was accepted for the mineralization in the Younger Paleozoic. That is why the recognition methods were the same as for the ore bodies in the Triassic.

The second development stage i.e., the recognition due to the numerous new boreholes, has led to the refuting the hitherto accepted model instead of to proving it, giving, however, no satisfactory data for a new model. It appeared that although the type of mineralization was the same as in the Triassic, the form was different.

To illustrate this thesis we will use fragments of the deposits Chechło and Poręba — Siewierz relatively well-recognized by boreholes (Fig. 3).

In those examples the Zn-Pb mineralization occurs both in the Triassic and in the Devonian. The Triassic mineralization in the Chechło deposit occurs in the ore-bearing dolomites developed in the Lower Muschelkalk. In aspect of form and composition the mineralization described is identical with that known from the other deposits in the Olkusz region being, however, distinctly poorer. In the Siewierz — Poręba deposit the ore mineralization in the Triassic displays a significant irregularity and position in the ore-bearing dolomites as well as in the Roethian rocks. The ores in the Roethian rocks are the most irregular in shape and the poorest.

A distinct difference between both the examples may be noticed in the occurrence of mineralization in the Paleozoic rocks. Mineralized intervals in the Chechło deposit occur distinctly irregularly. From the statistic point of view on their distribution in relation to the pre-Triassic paleorelief — 40% of them found in the boreholes correspond to the depth of 0-50 m below the paleorelief; in general — 70% lie in the interval of 0-100 m, while 30% — below 100 m. The neighbouring boreholes — situated up to 200 m from the other — display an occurrence of the mineralized intervals in the vertical distance reaching 160 m.

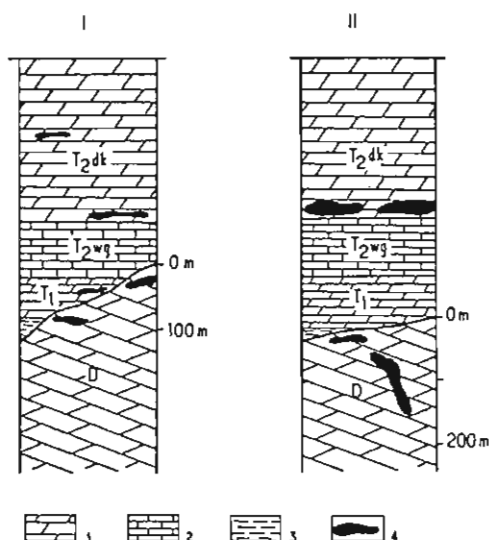
Is this one steep ore zone, or — do we have two flat nests of the horizontal dimension reaching some tens of meters and of vertical distance in between of about 160 m.

Fig. 4. Two hypothetical geometrical models of the ore bodies in the carbonate sediments of the Younger Paleozoic

I, II — models for deposits: I — of the western part of the area, II — of the eastern part of the area; 1 — dolomites; 2 — limestones; 3 — marls and claystones; 4 — ore bodies; T<sub>2</sub>dk — ore-bearing dolomites; T<sub>2</sub>wg — Gogolin Beds; T<sub>1</sub> — Roethian; D — Devonian

Dwa hipotetyczne modele geometryczne ciał rudnych w utworach węglanowych młodszego paleozoiku

I, II — modele złóż: I — zachodniej części obszaru, II — wschodniej części obszaru; 1 — dolomity; 2 — wapień; 3 — margle i ilowce; 4 — ciała rudne; T<sub>2</sub>dk — dolomity kruszczońskie; T<sub>2</sub>wg — warstwy gogolińskie; T<sub>1</sub> — roet; D — dewon



Each of the two interpretation possibilities involves a different method of the further recognition and a completely different type of resources evaluation.

Till present we have had no chance for an exact determination of the horizontal dimension of the ore bodies. Some attempts done due to the geophysics have not given the positive results.

The second example presented in the cross-sections is related to the Siewierz — Poręba deposit. A distinct connection between the occurrence of the mineralized intervals in the Devonian rocks and the paleorelief of that formation may be noticed. 90% of the intervals lie at the distance of 0-50 m from the relief. Some low metal contents have been found also in the sedimentary breccia of the Roethian age (S. Kurek, 1988), the fact being the characteristic feature there. Our knowledge on the horizontal distribution of the ore bodies and their geometric form is very insufficient since the borehole net of a distance of 200-500 m used (depending on the recognition stage) can only register the presence of the ore bodies. In such a situation we must only create hypothetical geometric models of the ore bodies attempting to motivate them on the basis of the hitherto obtained facts and hypotheses on formation mechanism of the Mississippi Valley-type deposits as well as using a comparison with the ore bodies developed in the Triassic rocks and well recognized due to the exploitation.

It must be stated that the ore bodies in the carbonate sediments of the Younger Paleozoic differ from those in the Triassic being connected not only with one stratigraphic-lithological horizon. The deposits in the Triassic occur in the horizon of the secondary ore-bearing dolomites developed at the boundary of two environments of different porosity and permeability — in the practically undeformed rocks. The development of the karst system, which formed mineralization traps (W. H. Callahan, 1964, 1977) was assigned to that horizon. That is why the nest forms are dominant in the Triassic.

Let us try to make geometric models of the ore bodies in the Younger Paleozoic sediments, being aware of a weak base we are forced to use.

The first model (referred to the western part of the area investigated, the Siewierz — Poręba, Siewierz, Rodaki — Rokitno Szlacheckie deposits):

1. The mineralization occurs in the dolomites and dolomite breccia in the top part of the pre-Triassic paleorelief on its culminations and slopes, generally not deeper than at the distance of 100 m from the relief.

2. The ore bodies are vertically scattered and are not assigned to the pre-Triassic paleorelief. It is quite possible that those bodies are both horizontal and slightly dipped, and steep in form of the ore chimneys.

Two hypothetical models presented above are shown in Fig. 4 together with the position of the ore bodies in the Triassic.

What are the causes of so different morphology of the ore bodies displaying the identical mineral composition?

It seems that the main cause represents a different development of the paleokarst systems. Those systems formed mineralization traps being responsible for the primary form of the ore bodies. An additional factor caused the better development of the karst system in the deposits corresponding to the second model. That factor may correspond to the tectonics and the deeper circulation of the waters causing the development of the vertical karst forms.

Two different mineralization models determine different approach to search and recognition of the ore bodies. Connection of the ore bodies with the pre-Triassic paleorelief represents an important criterion for the search for the deposits corresponding to the first model. This criterion determines at least the effective depth of recognition works. For the second model there exists only one important criterion, namely: a recognition of the areas displaying a distinct development of the karst events.

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Received: 29.12.1992

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## PROBLEMY MODELOWANIA ŻŁÓŻ RUD CYNKU I OŁOWIU TYPU MISSISSIPPI VALLEY W UTWORACH MŁODSZEGO PALEOZOIKU

### S t r e s z c z e n i e

Ciała rudne mineralizacji cynkowo-olowiowej typu Mississippi Valley w utworach węglanowych młodszego paleozoiku odznaczają się bardziej skomplikowaną geometrią niż ciała rudne w triasie. Próba określenia ich konfiguracji musi się z konieczności opierać na obserwacjach pośrednich z wierceń. Aktualnie możliwe jest skonstruowanie dwóch hipotetycznych modeli: pierwszego dotyczącego złóż zachodniej części NE obrzeżenia GZW, w których mineralizacja występuje w bliskim sąsiedztwie paleorelicfu przedtriasowego, i drugiego dotyczącego złóż wschodniej części, w których obserwuje się znaczny rozrzut w pionie ciał rudnych. W obu przypadkach, z uwagi na stosunkowo niewielkie rozmiary poziome ciał rudnych, ich dalsze rozpoznanie, a co za tym idzie określenie realnego modelu geometrycznego tych ciał, będzie bardzo kosztowne, a przez to niewykonalne w najbliższej przyszłości.