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The lead and zinc ore deposits in the vicinity of Chrzanów

The Zn-Pb ore deposit in the vicinity of Chrzanów consists of about 90 ore bodies of varied size. Mineralization occurs within the Middle Triassic dolomites in form of bed-shape sphalerite concentrations, replacing the host rocks and various aggregates of sphalerite and galena, infilling their voids. Ore distribution within the rock massif is determinated by lithology of the Triassic deposits and by tectonic structures but also an influence of paleohydrological factor on ore body origin is assumed. The effect of these factors operation is the ore concentration in some beds, named „ore horizons" and resulted the tabular form of ore bodies and their position concordant with bedding of surrounding rocks. The influence of tectonic factor also determinates internal variability of ore bodies. The described here deposit development could be assumed as typical for a part of the Silesian-Cracow ore province, located within the Upper Silesian Trough.

INTRODUCTION

The deposits of lead and zinc ores in the vicinity of Chrzanów (Fig. 1) are important ones in the world scale. It is valuated that from the beginning of their exploitation (XIV century) till the end of 1992 there have been mined ores, containing about 2.2 mln tons of zinc, about 0.7 mln tons of lead and several hundreds tons of silver. Also have been obtained about 100 thousands tons of iron from ores exploited from the half of XIX century in the weathering zone of zinc deposits (see S. Zaręczny, 1984) and several tens thousand tons of cadmium, extracted from zinc concentrates.

Actually only one mine (Trzebionka) continues exploitation, belonging together with the concentration plant to the Zakłady Górnicze Trzebionka S. A. (ZGT; Fig. 1). Its annual productivity is 2.1 mln tons of crude ore with Zn content of 3.5-3.9%, Pb content up 1.5 to 1.8%, 250 ppm of Cd and 10 ppm of Ag. This mine will act till total

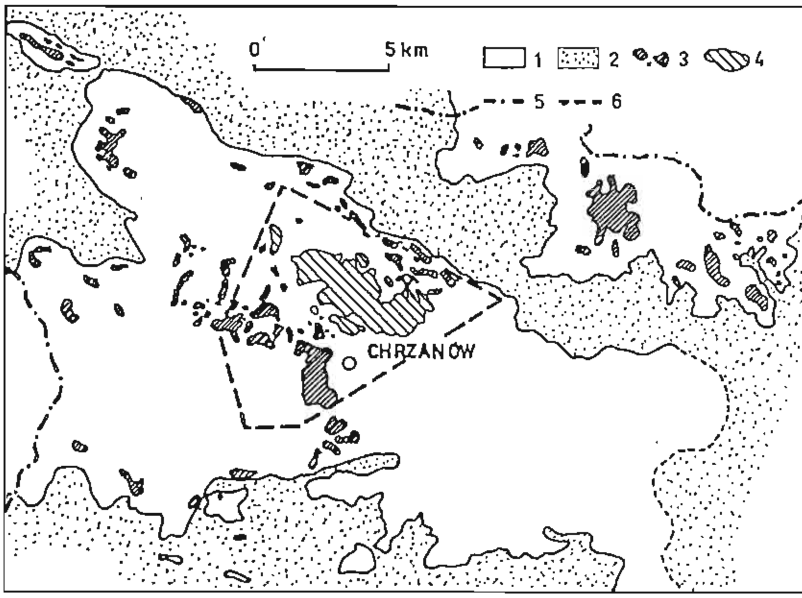

Fig. 1. The zinc and lead ore deposits nearby Chrzanów
1 — Triassic; 2 — Paleozoic; 3 — exploited ore bodies; 4 — ore bodies mined in the Trzebionka mine; 5 — boundaries of the historical district of ore mining; 6 — boundaries of the ZGT mining area
Złoża rud cynku i ołowiu w okolicach Chrzanowa
1 — trias; 2 — paleozoik; 3 — ciała rudne wyeksploatowane; 4 — ciała rudne eksploatowane w kopalni Trzebionka; 5 — granice historycznego okręgu górnictwa rud; 6 — granice obszaru górniczego ZGT

exhaustion of ore resourees on this area, that means about 15 years (according to the valuations from 1992).

The mining activity has favoured geologieal studies. Their results, mostly obtained from ore mines, have been foundations of many descriptions of geology of ore deposits in the Chrzanów region (among others: S. Zaręczny, 1894; F. Bartonec, 1906; F. Löwe, 1927; P. Assmann, 1946; H. Gruszezyk, 1956; I. Smolarska, 1968; P. Sobezyński, M. Szuwarzyński, 1974; P. Sobczyński et al., 1978; J. Pawłowska, M. Szuwarzyński, 1979). The results of newest studies and observations, from the period 1981-1991, are presented in this work together with archival data from mine and borehole documentations, prepared by geologists from Przedsiębiorstwo Geologiczne in Kraków. Part of discussed works are done within the limits of program of II Fund of M. Skłodowska-Curie.

GEOLOGICAL PATTERN

The area of mining activity in the vicinity of Chrzanów is located in southern part of the Silesian-Cracow ore province (Fig. 2G). It includes two structural units: the southern fragment of the Silesian-Cracow Monocline and a part of the Upper Silesian Trough, termed as orc depressions (see C. Kuźniar, 1929). The studics werc carried on within these depressions: the Chrzanów and Długoszyn ones (the exploitation of ore deposits has been finished at the beginning of XX century).

The ore depressions are indicated as a belt of the Triassic deposits, stretehing along the margin of the Upper Silesian Trough in direction approximate to NW-SE and framed with the exposures of the Upper Carboniferous and Permian deposits (Fig. 2G). Also deposits of the Jurassic, Tertiary and Quaternary oecur on this area (Figs. 2, 3). The Triassic rocks infill the broad synclines and troughs (the marginal zone of Bytom — Brodła; comp. S. Siedlccki, 1954). These structures have origined during the Early Cimmerian movemcnts, in period: Upper Triassic — Middle Jurassie, duc to renewing of the Variscan structures of thc Upper Silesian Trough (among others: S. Bukowy, 1974). Their next rebuilding, including also the broad folding in similar directions, is dated on the boundary of the Cretaceous and Tertiary or on Early Tertiary (a.o. S. Panek, M. Szuwarzyński, 1976).

The fold structures are accompanicd with faults (Fig. 3). Many of them, particularly that ones located in northern part of dcseribed area (Fig. 3A: the fault zone of Trzebinia — Będzin; after K. Bogaez, 1967), have distinct Early Cimmerian constituent but some had synsedimentary activity just during the Middle Triassic (see a.o. E. Hcrbich, 1981; M. Szuwarzyński, 1988). Finally the fault system has been definited during the development of thc Carpathian Foreland (a.o. S. Dżułyński, 1953; K. Bogacz, 1967; E. Herbieh, 1981). Partly it has origincd simultaneously with the post-Jurassic folding but partly with the formation of the Carpathian Foredcep in the Upper Mioccne. In the first episode has rebuilded the zone of Trzebinia — Będzin but in the second one have origincd the trough structures with parallel orientation.

GENERAL CHARACTERISTICS OF MINERALIZATION

Thc mincral composition of described ore deposits is similar to one, known from the other parts of the Silesian-Cracow ore province. Only one difference is relatively rare occurrence of marcasite and pyrite. Main ore minerals are sphalerite and galena. Within earlier exploited galmei ores have occurred abundantly smithsonite, monheimite, eerusite, hydrozincite and hemimorphite, recently being the accesory minerals. Similar eharacter have also other gangue minerals (without heavy metals) as: dolomite, caleite, chalcedony, quartz and barite.

Occurrenee of the lead and zine ores is limited to the Triassic deposits (Fig. 2B, C). In the Triassie sequenee the most important host rock for ores is so-ealled ore-bearing dolomite (*sensu* K. Bogacz et al., 1972): epigenetic dolosparite, replacing various lithological types of carbonate rocks (see J. Pawłowska, M. Szuwarzyński, 1979). Alost all mineable ore bodies, and most of smaller mineralizations are placed

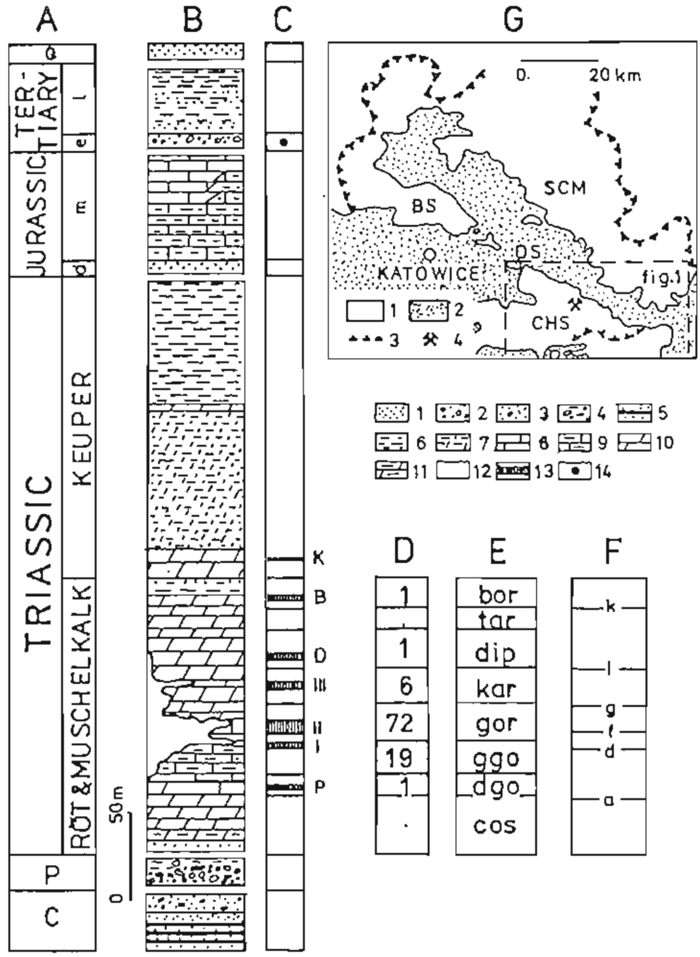

Fig. 2. The geological structure of studied area

A — stratigraphy: C — Carboniferous, P — Permian, d — Dogger, m — Malm, e — Early Tertiary, l — Late Tertiary, Q — Quaternary

B — lithology: 1 — sands and sandstones, 2 — residual deposits, 3 — arcosic sandstones, 4 — fanglomerates, 5 — sandstones with coal seams, 6 — clays and claystones, 7 — siltstones with dolomite intercalations, 8 — limestones, 9 — marls, 10 — pelitic and crystalline dolomites, 11 — dolomitic marls, 12 — epigenetic ore-bearing dolomite

C — ores distribution in profile: 13 — ore horizons (see Fig. 4), 14 — mineralization signs

D — distribution of metal resources (content in individual lithostratigraphic units in weight percents of total mass of Zn+Pb on ZGT area);

E — position of lithostratigraphic units, indicated on Figs. 5, 8

F — position of marker horizons (see Fig. 4, 5, 8)

G — location of studied area in the Upper Silesian ore province (geological sketch without deposits younger than the Muschelkalk ones): 1 — Triassic, 2 — Paleozoic, 3 — province boundaries (the extent of the ore-bearing dolomite after S. Śliwiński, 1969); SCM — Silesian-Cracow Monocline; ore depressions of: BS — Bytom , DS — Dlugoszyn, CHS — Chrzanów; Fig. 1 — location of Fig. 1

in it. Ores have been also found in other varieties of carbonate rocks and in the clastic ones (Fig. 2C).

The aggregates of ore minerals have complex structure and variable forms. Within non-weathered parts of ore deposits two form varieties could be distinguished: the replacements of host rock and infillings of its voids (see S. Dżułyński, M. Sass-Gustkiewicz, 1980). In first case they are massive, bedded and earthy aggregates of sphalerite, replaced partly or wholly the carbonate beds ore, more rarely — sphaleritic impregnations within them (see K. Bogacz et al., 1973*b*). The second variety is represented by covers on cavern walls, veins and veinlets, breccia matrixes ete. (see M. Sass-Gustkiewicz, 1985). The galmeies are similary developed (see F. Bartonec, 1906; S. Panek, M. Szuwarzyński, 1974). Moreover, within the weathering zone of the residual Tertiary deposits are known the supergenic and eluvial aggregates of galena (Fig. 2C). They have been noticed in exposured Triassic rocks, containing the veins of this mineral (S. Panek, M. Szuwarzyński, 1975).

REGULARITIES OF DISTRIBUTION OF ORE AGGREGATES

The ore aggregates occupy only several percent of volume of the Triassic carbonate rocks. It is important for practical aims to define the factors, influencing on variability of mineralization intensity, aggregate geometry and their location within blank massif.

Hitherto have been discussed the connection of the mineralization features with structure of rock massif (see M. Szuwarzyński, 1981, 1983*a*, *b*, 1984, 1988, 1989; M. Szuwarzyński, S. Panek, 1983). The undoubtful regularity of strueture of studied deposit is mentioned earlier co-occurrence of ores and epigenetic ore-bearing dolomite. It is regularity of regional range but the existence of this dolomite is not neecssary condition for ore occurrence.

More valuable for local scale is an occurrenee of mineralization within relatively thin package of beds of Lower Muschelkalk (Fig. 2D). Ignoring the aggregates within

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Budowa geologiczna opisywanego obszaru

A — stratygrafia: C — karbon, P — perm, d — dogger, m — malm, e — wczesny trzeciorzęd, l — późny trzeciorzęd, Q — czwartorzęd

B — litologia: 1 — piaski i piaskowce, 2 — utwory rezydualne, 3 — piaskowce arkozowe, 4 — fanglomeraty, 5 — piaskowce z pokładami węgla kamiennego, 6 — iły i iłowce, 7 — mułowce z wkładkami dolomitów, 8 — wapienie, 9 — margle, 10 — dolomity pelityczne i ziarniste, 11 — margle dolomityczne, 12 — epigenetyczny dolomit kruszconośny

C — rozmieszczenie kruszców w profilu: 13 — horyzonty rudne (patrz fig. 4), 14 — przejawy mineralizacji

D — rozkład zasobów metali (udziały w poszczególnych jednostkach litostratygraficznych podano w procentach wagowych całkowitej masy Zn+Pb na obszarze ZGT)

E — pozycja jednostek litostratygraficznych wymienionych na fig. 5, 8

F — położenie poziomów przewodnich (patrz fig. 4, 5, 8)

G — lokalizacja opisywanego obszaru w górnośląskiej prowincji złożowej (szkic geologiczny bez utworów młodszych od wapienia muszlowego): 1 — trias, 2 — paleozoik, 3 — granice prowincji (zasięg dolomitu kruszconośnego według S. Śliwińskiego, 1969), SCM — monoklina śląsko-krakowska; niecki rudne: BS — bytomska, DS — długoszyńska, CHS — chrzanowska; fig. 1 — lokalizacja fig. 1

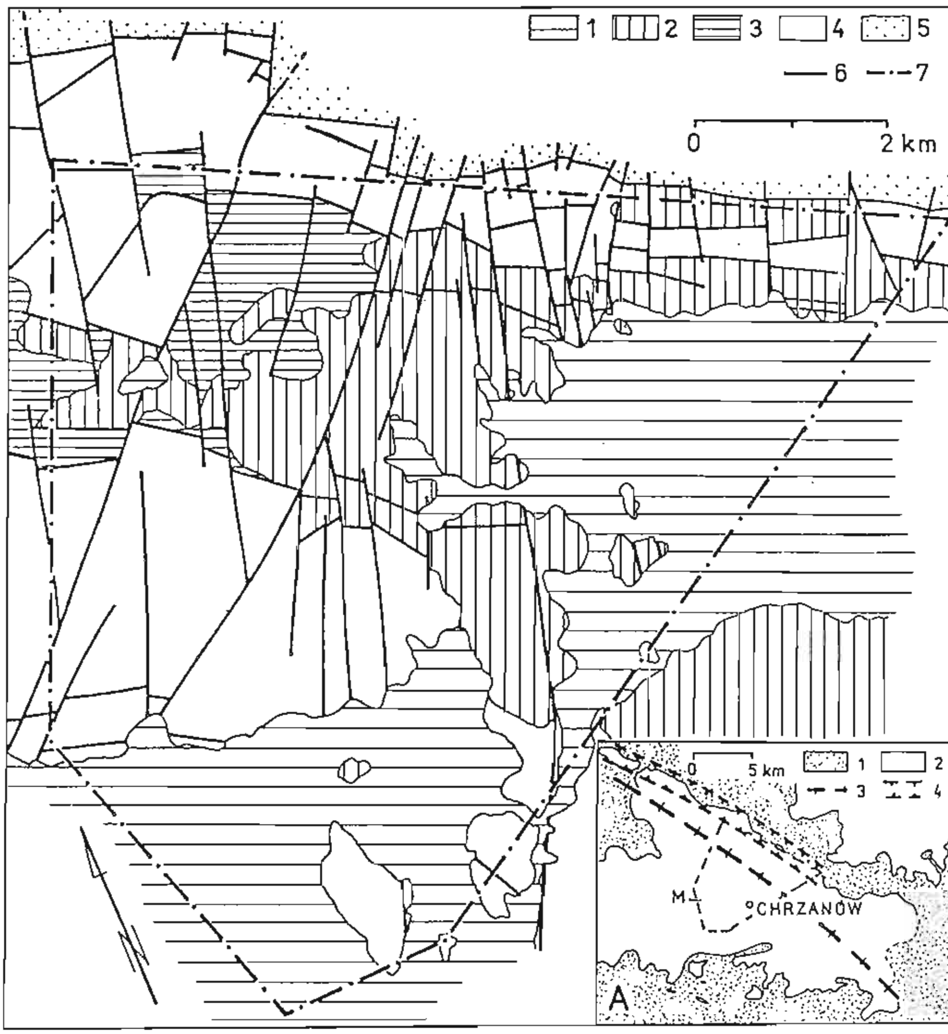

Fig. 3. The geological map of the ZGT mining area (without Quaternary)

1 — Tertiary; 2 — Jurassic; 3 — Upper Muschelkalk and Keuper; 4 — Röt, Lower and Middle Muschelkalk; 5 — Paleozoic; 6 — faults; 7 — ZGT mining area; A — geological sketch of the Chrzanów vicinity (without deposits younger than the Muschelkalk ones): 1 — Paleozoic, 2 — Triassic, 3 — axis of the Bytom — Brodła synclinal zone, 4 — Trzebinia — Będzin fault zone, M — ZGT mining area

Mapa geologiczna obszaru górniczego ZGT (bez czwartorzędu)

1 — trzeciorzęd; 2 — jura; 3 — górny wapień muszlowy i kajper; 4 — ret oraz dolny i środkowy wapień muszlowy; 5 — paleozoik; 6 — uskoki; 7 — obszar górniczy ZGT; A — szkic geologiczny okolic Chrzanowa (bez utworów młodszych od wapienia muszlowego): 1 — paleozoik, 2 — trias, 3 — przebieg osi strefy synklinalnej Bytomia — Brodeł, 4 — strefa uskokowa Trzebini — Będzina, M — obszar górniczy ZGT

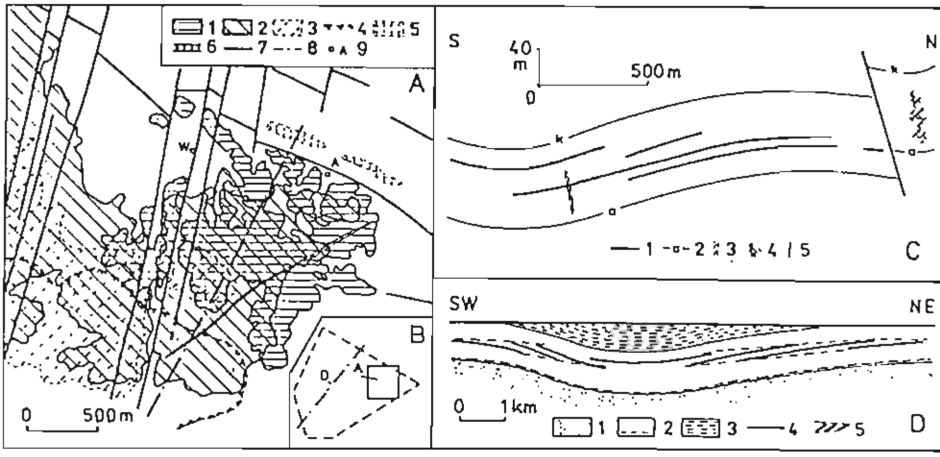

Fig. 4. The ore deposit structure in the Chrzanów Depression

A — distribution map of ore bodies: 1 — within the I ore horizon, 2 — within the II ore horizon, 3 — within the III ore horizon, 4 — extent of occurrence of ore aggregates within the D horizon, 5 — extent of occurrence of ore veinlets (as the sole form of mineralization), 6 — calcite-barite veins with sulfides, 7 — faults, 8 — section C, 9 — shafts location: A — Andrzej, W — Włodzimierz

B — location of map A and section D on the ZGT mining area

C — ore deposit cross-section: 1 — ore bodies within horizons I, II, III and D, 2 — marker horizons (see Fig. 2F), 3 — calcite-barite veins with sulfides, 4 — zones with sulfide veinlets, 5 — faults

D — reconstruction of the Chrzanów depression before the Jurassic transgression, with location of ore bodies: 1 — Paleozoic deposits, 2 — carbonate rocks of Triassic, with insulating layer at the base (lowermost Röt), 3 — clastic deposits of Triassic age (Upper Muschelkalk and Keuper), 4 — peneplanation surface of Jurassic age, 5 — supposed paleohydrogeological zone with marked ore bodies

Budowa złoża w niecce chrzanowskiej

A — mapa rozmieszczenia ciał rudnych: 1 — w I horyzoncie rudnym, 2 — w II horyzoncie rudnym, 3 — w III horyzoncie rudnym, 4 — zasięg występowania skupień kruszców w horyzoncie D, 5 — zasięg występowania żyłek kruszcowych (jako jedynej formy mineralizacji), 6 — żyły kalcytowo-barytowe z siarczkami, 7 — uskoki, 8 — linia przekroju C, 9 — lokalizacja szybów: A — Andrzej, W — Włodzimierz

B — lokalizacja mapy A i przekroju D w obrębie obszaru górniczego ZGT

C — przekrój przez złoże: 1 — ciała rudne w horyzontach I, II, III i D, 2 — poziomy przewodnie (fig. 2F), 3 — żyły kalcytowo-barytowe z siarczkami, 4 — strefy występowania żyłek siarczkowych, 5 — uskoki

D — rekonstrukcja niecki chrzanowskiej przed transgresją jurajską, z rozmieszczeniem ciał rudnych: 1 — utwory paleozoiczne, 2 — utwory węglanowe triasu z warstwą izolującą w spągu (najniższy ret), 3 — utwory klastyczne triasu (górny wapień muszlowy i kajper), 4 — jurajska powierzchnia zrównania, 5 — postulowana strefa paleohydrogeologiczna z zaznaczonymi ciałami rudnymi

the Tertiary deposits (they have supplied several hundreds tons of galene with high silver content), the mineable ore bodies have been found earlier and are located now within the package about 40 m thick but the thickness of whole recognized sedimentary sequence, from Upper Carboniferous up to Quaternary, exceeds 1000 m on that area.

In discussed scale of phenomena the very significant are two other interrelated regularities: the tabular form of most of ore aggregates and the tendency of their occurrence in definited lithostratigraphic beds, named „ore horizons". In the vicinity

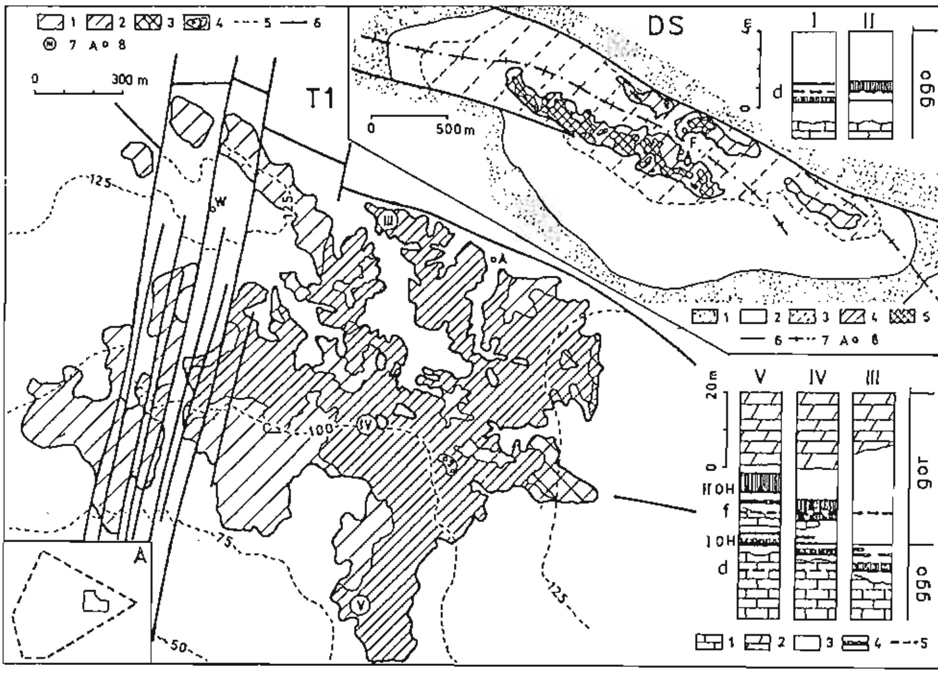

Fig. 5. The structure of ore bodies within the I ore horizon

DS — ore bodies on area of the Długoszyn Syncline (location on Fig. 2G): 1 — Paleozoic, Röt and Muschelkalk, 2 — pelitic dolomites, limestones and marls, 3 — ore-bearing dolomite, 4 — extent of galena-galmei mineralization, developed as on profile I (cut-off grade 5% of Zn-Pb), 5 — extent of galmei mineralization with relicts of massive metasomatic sphaleritic aggregates, developed as on profile II (cut-off grade 12% of Zn+ Pb), 6 — faults, 7 — syncline axes, 8 — shafts of old mines: A — Amalia, F — Friedrich

T1 — ore body T1 in the mine Trzebionka: 1 — metasomatic aggregates of sphalerite with cut-off grade 2.5% Zn+Pb, 2 — metasomatic aggregates of sphalerite with galena veins with cut-off grade 6.5 % of Zn+Pb, 3 — galmeis developed in both mineralization types, 4 — solution-collapse breccia (section of Fig. 8), 5 — isolines of the marker horizon d (see Fig. 2F), 6 — faults, 7 — location of profiles III-V, 8 — shafts of the Trzebionka mine: A — Andrzej, W — Włodzimierz

A — location of map T1 on the mining area

I-V — profiles of the I ore horizons: 1 — limestones and marls, 2 — pelitic and crystalline dolomites, 3 — ore-bearing dolomite, 4 — ore aggregates, 5 — marker horizons d, f (see Fig. 2F), ggo, gor — lithostratigraphic units (see Fig. 2E)

Budowa ciał rudnych w I horyzoncie rudnym

DS — ciała rudne na obszarze niecki długoszyńskiej (lokalizacja na fig.2G): 1 — paleozoik, ret i wapień muszlowy, 2 — dolomity pelityczne, wapienie i margle, 3 — dolomit kruszconośny, 4 — zasięg mineralizacji galenowo-galmanowej rozwiniętej jak na profilu I (zawartość brzeżna 5% Zn+Pb), 5 — zasięg mineralizacji galmanowej z reliktami masywnych metasomatycznych skupień sfalerytowych rozwiniętej jak na profilu II (zawartość brzeżna 12% Zn+Pb), 6 — uskoki, 7 — osie synklin, 8 — szyby dawnych kopalń: A — Amalia, F — Friedrich

T1 — ciało rudne T1 z kopalni Trzebionka: 1 — metasomatyczne skupienia sfalerytu spełniające zawartość brzeżną 2,5% Zn+Pb, 2 — metasomatyczne skupienia sfalerytu z żyłami galeny spełniające zawartość brzeżną 6,5% Zn+ Pb, 3 — galmany rozwinięte na obu typach mineralizacji, 4 — brekcja zawałowa (przekrój na fig. 8), 5 — warstwice poziomu przewodniego d (patrz fig. 2F), 6 — uskoki, 7 — lokalizacja profilów III-V, 8 — szyby kopalni Trzebionka: A — Andrzej, W — Włodzimierz of Chrzanów have been located seven of such horizons (Fig. 2C) but tendency of similar metal concentrations seems to have various reasons.

The ore horizons P, B and K but also partly D one contain the mineralization with indices of geochemical anomalies, sometimes with regional extent, without signs of transformations in host rocks. It seems that these beds were enriched with heavy metals just during their transformations.

That problem looks like otherwise in the I, II and III ore horizons. Differently from mentioned earlier cases there is not observed lateral continuity of mineralization but could be distinguished within them the ore bodies with sharp boundaries. In the Chrzanów Depression these bodies are located en-echelon: in higher horizons the ore aggregates are placed more close to the depression center (such regularity relates also to part of ores within the horizon D; Fig. 4C). These bodies are found within the sharply contoured zone (Fig. 4D), limited with surfaces resembling the ones separating zones with different dynamics within the aquifer.

It is possible to explain described situation as the result of influence of paleohydrogeological relations within Triassic aquifer on the epigenetic ore generating processes, probably during the period forecoming the Jurassic transgression. Due to that the meaning of term „ore horizont" in relation to discussed units, becomes more approximate to the term of O. Rove (1947; see also E. L. Ohle, 1951; J. J. Dozy, 1970) than to strictly lithostratigraphic definition, used by H. Gruszczyk (1956), I. Smolarska (1968) and others. The zone within aquifer would be determinated from one side by rocks properties (chemistry, porosity, permeability etc.) but from other one — by flow conditions, definited by water level position and hydraulic gradient within rock massif. Among factors, determining the flow conditions, beside of lithological variability of massif, also significant one is tectonic structure of rock massif, both occurrence of broad folds and faults.

The fault tectonics has influenced on the ore distribution also in another way. Within tabular ore bodies majority of breccias is related with it. Moreover, the faults and accompanying fractures are the places of ore aggregates, oriented obliquely to the bedding of host rocks (see M. Szuwarzyński, 1977, 1991). Most often they are sphaleritic veinlets, less than 1 mm thick, occurring in the assemblages with complicated geometry and varied density. More rare are the galena and galena-sphaleritic veins, from 1 to 4 cm thick, and similar calcite veins with barite, iron sulfides and galena.

The most of these forms of mineralization occurs in southern part of the fault zone Trzebinia — Będzin (Fig. 4). More rarely they are found along other faults and flexures. Mineralization is noticed both within ore-bearing dolomite and in other carbonate rocks, locating in the interval of about 100 m. Metals content changes there from 0.5 to 1.0% but locally are found little, irregulary placed enrichments (there are traces of their exploitation in the XIXth century mines).

A — lokalizacja mapy T1 na obszarze górniczym

I-V — profile I horyzontu rudnego: 1 — wapienie i margle, 2 — dolomity pelityczne i ziarniste, 3 — dolomit kruszconośny, 4 — skupienia kruszców, 5 — poziomy przewodnie d, f (patrz fig. 2F), ggo, gor — jednostki litostratygraficzne (patrz fig. 2E)

STRUCTURE OF ORE BODIES

The boundaries of mineable ore bodies (about 90 units of various size) have been determinated applying criteria of cut-off grade content of metals. These criteria have changed in time that has resulted in changes of size and internal structure of any ore body (see Fig. 5). The range of such variability and also other features have been highly determinated by the body occurrence within definited ore horizon.

THE I ORE HORIZON

The majority of ore bodies nearby Chrzanów (about 70 units) occurs in that position. They were exploited in the fault zone Trzebinia — Będzin and in southern part of the Chrzanów Depression (Fig. 2G). In fault zone the ore bodies have occurred in a belt about 2 km wide. Within it are noticed a number of little fold structures, parallel to axes of ore synclines, and a bundle of several faults of similar orientation, crossed by many perpendicular dislocations (Fig. 3; see also F. Löwe, 1927; K. Bogacz, 1967). The relation between the occurrence of described bodies and faults is undefinited (such one refers to existing there vein mineralization — see Fig. 4).

All exploited ore bodies were of little size and had high variability. Amount of zinc and lead, obtained from individual units, changed from several to a dozen or so thousands tons. The value of ore was higher due to relatively large silver content (over 200 ppm) and accessibility of ore deposits. The exploited ore contained carbonate galmeies and galena. The found relicts of massive aggregates of sphalerite document the primary sulfide character of mineralization (see C. Kuźniar, 1930). The significant degree of oxidation of primary ore is connected with their, relatively early, exposure (their bed exposures are covered with the Jurassic deposits).

The studied by author principle of ore bodies from the fault zone are the units from the deposit in the Długoszyn Depression, in north-western part of described area (Fig. 5; M. Szuwarzyński, S. Panek, 1977). This deposit consists of four bodies, elongated parallel to axes of fine folds. Any body contains metasomatic ore aggregates in two beds. Lateral variability of mineralization intensity within any bed has a basic importance for a course of ore bodies boundaries. These boundaries, determinated for the cut-off grade content of 5% Zn+Pb, were parallel to bed strikes. On long distances their course was nearly rectilinear but on elevations of fold axes — sickle-shaped. The bodies dimensions along strike changed from 400 up to 1600 m but along the inclination — from 60 to 250 m, at calculated thickness from 1.2 to 1.3 m. If the criterion of cut-off grade content is enlarged up to 12% Zn+Pb (such requirements for ore were applied in the sixties of XIX century), the sizes of majority of bodies would be significantly decreased but others would be partitioned for many finer units or completely diminished (Fig. 5).

The ore bodies from the interiors of ore depressions are known from the area westward from Chrzanów (see Fig. 1) and from the Trzebionka mine (Fig. 5; see M. Szuwarzyński, 1986). In first case there are several objects similar to described examples, but in second one — it is only one ore body but different in any points. Its parameters are: about 2000 m along the strike and 1200 m along the dip, with average thickness over 1.8 m (locally up to 6 m). Except of eastern edge, where occur also galmeies, it contains primary sulfide mineralization. Amount of metals within it is estimated for about 150 thousands tons (with silver content of 15–20 ppm and cadmium of about 250 ppm for one ton of ore).

This body is composed of sphaleritic aggregates, replacing the series of ore-bearing dolomite. These aggregates are oriented en-echelon, they occur in any higher bed, parallel to diagonal contact of ore-bearing dolomite with limestones (Fig. 5). Due to that the course of top and bottom of ore body is distinctly oblique to bedding of host rocks.

The lateral boundaries of ore body, determinated for the cut-off grade content of 2.0% Zn+Pb, are in general concordant with natural boundaries of ore aggregates (decreasing of the cut-off grade content does not practically an influence on their change). But assuming of the criterion of 6.5% Zn+Pb involves nearly 50% decrease of body surface.

The contour of described unit, in difference from straight or sickle-shaped contours of bodies from fault zone, is complicated. But it is noticed their concordance with main structural directions, with strikes of beds within surrounding the body rock massif and with course of some faults (Fig. 5).

THE II ORE HORIZON

Ten ore bodies were definited in this horizon. Most of them were very similar to units from I ore horizon. Distinctly different were two ones: one of them from old Matylda mine (Fig. 8) and second one — exploited now in the Trzebionka mine (Fig. 6).

In first case it was the unit, containing over 150 thousands tons of Zn+Pb, with silver content in ore over 70 ppm. Its main component was the galmei-galena ore with relatively high content of lead (5–6%). There dominate the aggregates of monheimite and smithsonite, replacing series of ore-bearing dolomite and vein-shaped and nest-shaped concentrations of galena (see F. Bartonec, 1906; S. Panek, M. Szuwarzyński, 1974).

In second case is one of the largest ore bodies in the Upper Silesian ore province. Amount of metals within it is valuated for about 3 mln tons of Zn+Pb, with Ag content of 10 ppm and Cd — 300 ppm. Within boundaries, determinated for the cut-off grade content of 2.0% of Zn+Pb, its dimensions are: along strike over 5 km, along dip — from 0.8 to 2.3 km. Its thickness on the most of area changes from 2 up to 6 m (most often it is 4 m). Locally, close to the perpendicular faults to depression axis, occur „thickennings", where it increases up to dozen or so meters but in some places — up to several tens of meters (Fig. 6C).

The contour of described body reflects the same geometric regularities as in the largest ore body within the I ore horizon: they are parallel to course of the Triassic beds and of some dislocations. Similar regularities determinate the position and course of boundaries of non-mineralized enclaves within the body (Fig. 6).

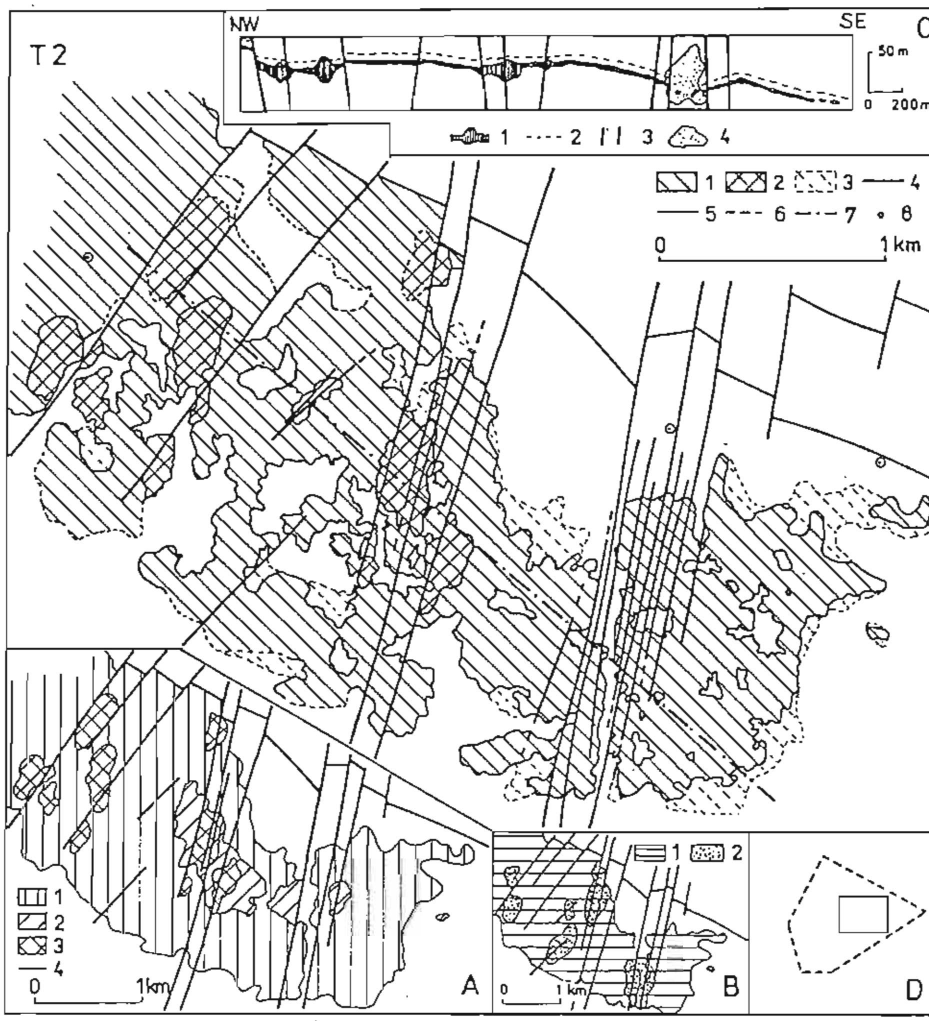

Fig. 6. The structure of ore bodies within the II ore horizon

The ore body T2 within the II ore horizon (the Trzebionka mine): 1 — mineralization within the II ore horizon, 2 — breccias overpassing boundaries of the II ore horizon, 3 — signs of gangue mineralization of carbonate--chalcedony type with traces of sulfides, 4 — faults, 5 — boundaries of ore body definited in the mine excavations, 6 — boundaries of ore body definited according to borehole data, 7 — section C, 8 — location of mine shafts

A— distribution of ore aggregates with various textures: 1 — dominance of aggregates of type host rock-replaced with ores, 2 — dominance of aggregates of type infilled voids of host rocks, 3 — dominace of breccias, 4 — faults

B — occurrence of ore aggregates related with scattering dolomites: 1 — area with ore aggregates origined due to disaggregation of ore-bearing dolomite, 2 — area with scattering dolomites with galena

C — schematic section of ore body within the II ore horizon (mineralization within horizons I, III and D is not indicated): 1 — ore body, 2 — marker horizon g (see Fig. 2F), 3 — faults, 4 — extent of disaggregation and brecciation of dolomite within fault zone

D — location of T2 on the mining area

The main component of described ore body is sulfide mineralization with unfound in other cases texture variability (Fig. 6A). There prevail the ore aggregates replacing host rocks but also significant are the ores infilling voids also of breccias matrix. Except of it, on margins of body could be distinguished the zone of epigenctic mineralization with drusy dolomite and chalcedony with a little amount of sulfides.

The sphalerite aggregates, replacing beds of ore-bearing dolomite, are older than ores, infilling voids (there have been no signs of mineralization found, which could be assumed as recent epigenetic dolomitization but the occurrence of which is suggested by some scientists, among others: K. Bogacz et al., 1970, 1972; M. Sass-Gustkiewicz, 1985). Such infillings, including also matrixes of various breccias, have several-stage development but it is difficult to find there the mineral succession, defined in other parts of the Upper Silesian ore province (M. Sass-Gustkiewicz, 1975, 1985).

It should be added that many of mineralized breccias are of tectonic origin. There occur also the collapse breccias, it means ones with genesis connected with solution effect on rocks. But rarely it is possible to relate them with so-called hydrothermal karst (*sensu* S. Dżułyński, 1976; comp. M. Sass-Gustkiewicz et al., 1982). Process of origin of solution-collapse breccias has the "non-productive" character but it distinctly determinated the recent ore deposit image.

Such principle could be the development of little breccia structure in eastern part of studied area (Figs. 5, 7). It has began with disaggregation of ore-bearing dolomite in some beds on area of several thousands of square meters within the ore body in the I ore horizon (Fig. 5). The dolomitic rock has been transformed into the aggregate of carbonate grains of silt and sand size (see K. Bogacz et al., 1973*a*). It has been accompanied with the leaching of several up to a dozen or so percent of volume of rock substance. The volume loss in any bed has been compensated with subsidence of overlying beds that the empty spaces of cavern type have not origined. Within subsiding beds have taken place the widening of fractures, rock block displacements and at the end — an origin of deposits of crackle breccia type. The breccia extension in profile

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Budowa ciał rudnych w II horyzoncie rudnym

Ciało rudne T2 w II horyzoncie rudnym (kopalnia Trzebionka): 1 — okruszcowanie w obrębie II horyzontu rudnego, 2 — brekcje przekraczające granice II horyzontu rudnego, 3 — przejawy płonnej mineralizacji węglanowo-chalcedonowej ze śladami siarczków, 4 — uskoki, 5 — granice ciała rudnego określone w wyrobiskach kopalni, 6 — granice ciała rudnego określone na podstawie wierceń, 7 — przekrój C, 8 — lokalizacja szybów kopalni

A — rozmieszczenie skupień kruszców o różnych teksturach: 1 — przewaga skupień typu zastępowania skały goszczącej przez kruszce, 2 — przewaga skupień typu wypełnień pustych przestrzeni w skałach goszczących, 3 — przewaga brekcji, 4 — uskoki

B — występowanie skupień kruszców związanych z rozsypliwymi dolomitami: 1 — obszar zajęty przez skupienia kruszców powstałe przed dezagregacją dolomitu kruszconośnego, 2 — obszar występowania rozsypliwych dolomitów z galeną

C — schematyczny przekrój przez ciało rudne w II horyzoncie rudnym (nie zaznaczono mineralizacji w horyzontach I, III i D): 1 — ciało rudne, 2 — poziom przewodni g (patrz fig. 2F), 3 — uskoki, 4 — zasięg dezagregacji i zbrekcjowania dolomitu w strefie przyuskokowej

D — lokalizacja T2 na obszarze górniczym

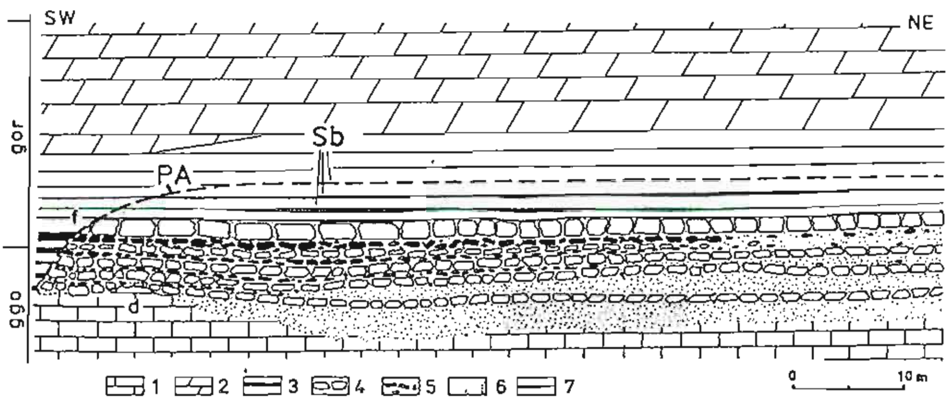

Fig. 7. The cross-section of the breccia structure, indicated on Fig. 5

1 — limestones and marls; 2 — pelitic dolomites; 3 — ore-bearing dolomite with metasomatic aggregates of sphalerite; 4 — blocks and pieces of dolomites; 5 — blocks and pieces of shpaleritic ore; 6 — dolomitic sand, 7 — aggregates of Schalenblende; PA — balance roof over the collapse breccia; Sb — inter-strata spaces infilled with Schalenblende; f, d — marker horizons (see Fig. 2F); ggo, gor — lithostratigraphic units (see Fig. 2E)

Przekrój przez strukturę brekcjową zaznaczoną na fig. 5

1 — wapienie i margle; 2 — dolomity pelityczne; 3 — dolomit kruszconośny z metasomatycznymi skupieniami sfalerytu; 4 — bloki i okruchy dolomitu; 5 — bloki i okruchy rudy sfalerytowej; 6 — piasek dolomitowy; 7 — skupienia blendy skorupowej; PA — sklepienie równowagi nad brekcją zawałową; Sb — rozwarstwienia wypełnione blendą skorupową; f, d — poziomy przewodnie (patrz fig. 2F); ggo, gor — jednostki litostratygraficzne (patrz fig. 2E)

is limited by pressure arch, located from several up to a dozen or so meters above the structute base (Fig. 7).

The breccia matrix is a dolomitic sand, left *in situ* or redeposited as internal deposits or clastic dykes. Most often it has preserved as loose aggregate of carbonate grains (in other places it is often cemented or could be recrystallized or partly replaced with younger ores).

The effect of described process, except of ore deposit destruction in the I ore horizon, is a setting of conditions for origin of ore concentrations. The places of their forming are the inter-beds spaces, open during saging of dolomitic massif (Fig. 7). They have been infilled with aggregates of Schalenblende.

Similar structures are known from many places, commonly located nearby to faults. Other group of them is refered to the Tertiary disaggregation of ore-bearing dolomite (K. Bogacz et al., 1973*a*). They occur in zones, within which the destruction of ore-bearing dolomite series have taken place in section up to several tens of meters thick and where occurred almost complete leaching of existed there ore concentrations. In some zones, affecting by such process (Fig. 6B) has origined the youngest mineralization, represented by19 „vermicular" veins of galena within disaggregated dolomites (see K. Bogacz et al., 1973*a*).

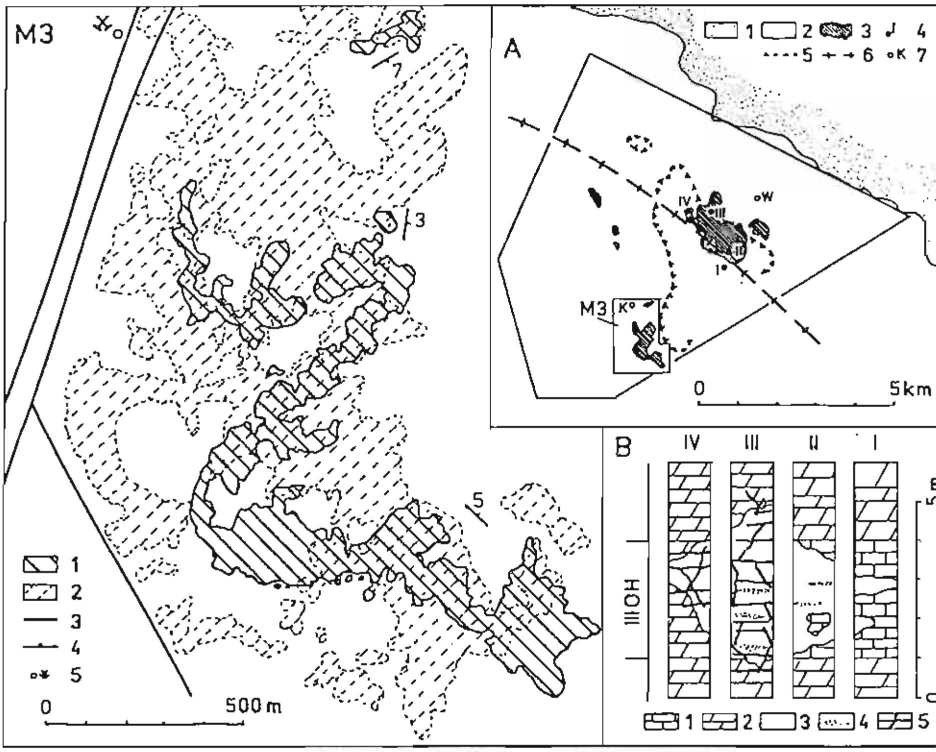

Fig. 8. The structure of ore bodies within the III ore horizon

The ore bodies M3 within the III ore horizon in old mine Matylda: 1 — ore bodies within the III ore horizon, 2 — contour of ore bodies within the II ore horizon, 3 — faults, 4 — strike and dip of the Triassic beds, 5 — Karol shaft

A — mineralization within the III ore horizon on the ZGT mining area, with location of map M3: 1 — Paleozoic, 2 — Triassic, 3 — areas with mineralization within the III ore horizon, 4 — location of profiles I-IV, 5 — occurrence of ore aggregates within the D horizon, 6 — axis of the Chrzanów Depression, 7 — shafts: W — Włodzimierz, K — Karol

B — profiles of the III ore horizon in the Trzebionka mine: 1 — limestones, 2 — pelitic and grained dolomites, 3 — ore-bearing dolomite, 4 — metasomatic ore aggregates, 5 — ore veins

Budowa ciał rudnych w III horyzoncie rudnym

Ciała rudne M3 w III horyzoncie rudnym z nieczynnej kopalni Matylda: 1 — ciała rudne w III horyzoncie rudnym, 2 — zarys ciał rudnych w II horyzoncie rudnym, 3 — uskoki, 4 — bieg i upad warstw triasowych, 5 — szyb Karol

A — mineralizacja w III horyzoncie rudnym na obszarze górniczym ZGT z lokalizacją mapy M3: 1 — paleozoik, 2 — trias, 3 — obszary z mineralizacją w III horyzoncie rudnym, 4 — lokalizacja profilów I-IV, 5 — występowanie skupień kruszców w horyzoncie rudnym D, 6 — przebieg osi synkliny chrzanowskiej, 7 — szyby: W — Włodzimierz, K — Karol

B — profile III horyzontu rudnego w kopalni Trzebionka: 1 — wapienie, 2 — dolomity pelityczne i ziarniste, 3 — dolomit kruszconośny, 4 — metasomatyczne skupienia kruszców, 5 — żyły kruszcowe

THE III ORE HORIZON

Hitherto have been detected seven ore bodies within this horizon (Fig. 8). Two of them are well recognized, they were exploited in old Matylda mine. Their dimensions along strike changed from several hundreds of meters up to about 2 km, but along the dip — from several tens up to 200 m, with thickness up to 1.8 m. They differ from other described units with their composition, consisting of aggregates of voids infilling type, mainly veins and covers on cavern walls. Often noticed phenomenon is disaggregation of ore-bearing dolomite in surroundings of ores.

The recognized bodies from Trzebionka are probably a bit larger (Fig. 8A), particularly in thickness (locally over 4 m). It seems that such thickness is related with thickness of series of ore-bearing dolomite in studied profile (Fig. 8B).

CONCLUSIONS

The described here deposit of zinc and lead ores from the ore synclines nearby Chrzanów corresponds with standart MVT (Mississippi Valley-type — see M. Sass-Gustkiewicz et al., 1982). Among ore deposits on the Silesian-Cracow area the most similar one is the deposit in the Bytom Syncline (Fig. 2G). In both cases they are multi-layered deposits, with similar position of ore horizons, in both prevail the concentrations of type „replacement of host rock" (C. Kuźniar, 1929; H. Gruszczyk, 1956; see also M. Szuwarzyński, 1984). The mentioned features differ them from the deposits located on the Silesian-Cracow Monocline. It confirms the hypothese of C. Kuźniar (1929) on possibility of partition of ore province for zones with other development of mineralization, placed parallel to northern border of the Upper Silesian Basin.

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ZŁOŻA RUD CYNKU I OŁOWIU W OKOLICACH CHRZANOWA

Streszczenie

Obszar górnictwa rud cynku i ołowiu w okolicach Chrzanowa jest częścią śląsko-krakowskiej prowincji złożowej. Zasoby metali w obrębie dawnych i czynnych pól górniczych szacowane są tu na 3 mln t cynku i ok. 1,1 mln t ołowiu oraz kilkaset ton srebra, kilkadziesiąt tysięcy ton kadmu i ponad 100 tys. t limonitowych rud żelaza. Ich eksploatację, kontynuowaną dziś w kopalni Trzebionka, rozpoczęto na początku XIV w.

Opisywane złoża występują w węglanowych utworach triasu. Utwory te budują element synklinalny zwany niecką rudną. Niecka, a także wiele spośród występujących tu uskoków, powstały w wyniku ruchów starokimeryjskich. Wszystkie te struktury były kilkakrotnie przebudowane podczas formowania przedgórza Karpat.

Większość kruszców skupia się w pakiecie warstw dolnego wapienia muszlowego o grubości ok. 40 m. W obrębie tego pakietu widoczna jest tendencja do występowania kruszców w określonych litostratygraficznie warstwach, zwanych horyzontami rudnymi. Poza nimi także spotykane są przejawy mineralizacji, najczę-

ściej zespoły żył i żyłek o skomplikowanej geometrii i zróżnicowanej gęstości, zazwyczaj występujące w strefach uskokowych.

Wyróżniono siedem horyzontów rudnych. W trzech, oznaczonych symbolami I, II, III, znane są ciała rudne nadające się do eksploatacji. Ciała te składają się ze skupień sfalerytu i galeny lub też produktów ich wietrzenia. W skupieniach tych kruszce zastępują skały węglanowe lub też wypełniają puste przestrzenie w tych skałach.

Rozpoznano ok. 90 ciał rudnych. Zalegają one kulisowo: im wyższy horyzont rudny, tym bliżej osi niecki znajdują sie skupienia kruszców. Dlatego też największy zasięg ma mineralizacja w I horyzoncie, a najmniejszy — w III horyzoncie. Ciała rudne w większości przypadków składały się ze skupień sfalerytu typu zastąpień. Inne skupienia kruszców, głównie żyły i żyłki, odgrywają mniejszą rolę. Okruszcowane brekcje (najczęściej są to brekcje tektoniczne) występują wyłącznie w II horyzoncie rudnym. W tej samej pozycji występują też „robaczkowe" żyły galeny w rozsypliwych dolomitach, uważane za najmłodszy przejaw mineralizacji.

Wszystkie ciała rudne odznaczają się płytową formą i stosunkowo ostrymi granicami. Rozmiary poszczególnych ciał są zróżnicowane. W większości przypadków wahają się one w granicach od 400 do 2000 m po biegu i od 60 do 250 m po upadzie, przy grubości od 1,2 do 1,8 m. Napotkano też kilka większych jednostek. Jedną z nich było ciało z I horyzontu rudnego w kopalni Trzebionka (ok. 2000 m po biegu i 1200 po upadzie, przy grubości dochodzącej do 6 m). Pozostałe znane są z II horyzontu.

Wśród nich znajduje się największe ciało rudne na opisywanym terenie i jedno z największych w prowincji śląsko-krakowskiej. Jest ono obecnie eksploatowane w kopalni Trzebionka. Jego rozmiary po biegu wynoszą ponad 5 km, a po upadzie od 0,8 do 2,3 km. Grubość ciała na przeważającym obszarze waha się od 2 do 6 m, a lokalnie, w pobliżu uskoków, występują „zgrubienia", w których wzrasta ona nawet do kilkudziesięciu metrów.

Opisane złoże rud cynku i ołowiu z okolic Chrzanowa ujawnia wiele podobieństw do złóż w nieckach rudnych w okolicach Bytomia. W obu przypadkach są to złoża wielowarstwowe, z podobną lokalizacją horyzontów rudnych. W obu też przeważają skupienia kruszców typu zastąpień. Odróżnia je to od złóż położonych na monoklinie śląsko-krakowskiej, zwłaszcza zaś od złóż olkuskich.