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Geologic setting and ore mineralization characteristics of the Myszków area (Poland)

This study focusses on geological setting and mineralization zones of newly-discovered polymetallic ore deposits of Myszków (Poland). In the Myszków deposit a few genetically-diversified ore formations have been distinguished, the most important of which are: molybdenum-tungsten-copper formation of stockwork type, pyrite-copper formation of sedimentary provenance and porphyry eopper formation.

INTRODUCTION

Boreholes were taken in the years 1982–1990 to identify the Myszków molybdenum-tungsten-copper ore deposit. These investigations were based on previous work by K. Piekarski (1971*a*, *b*, 1974). The results derived from the boreholes enabled recognition of the geological-structural conditions of the deposit and provided information on the ore mineralization of Early Palaeozoic sequences and the igneous rocks that pierce them.

GEOLOGIC SETTING OF THE MYSZKÓW DEPOSIT AREA

The Myszków deposit is located in the northeastern part of the Kraków – Częstochowa Upland, which belongs to the segment of the Mid-European Palaeozoic Platform featuring the Caledonian consolidation (J. Znosko, 1983).

Three principal structural stages can be distinguished in the geological structure of the area described (starting from the top): cover, Variscan and Caledonian stages.

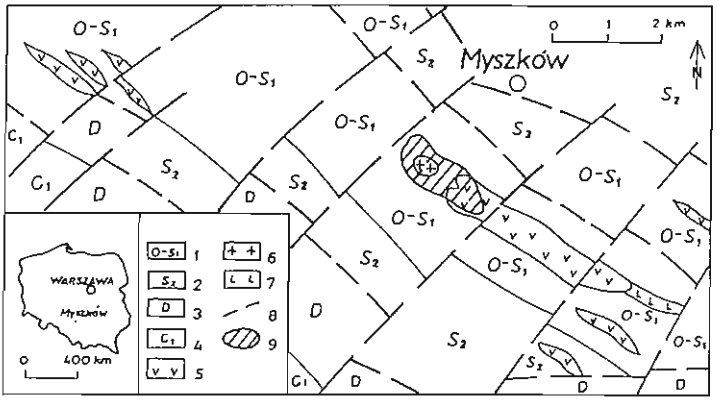


Fig. 1. Sector of the geologic map of the Myszków area without Cenozoic, Mesozoic and Permian rocks
1 — Ordovician-Lower Silurian; 2 — Upper Silurian; 3 — Devonian; 4 — Lower Carboniferous; 5 — porphyry; 6 — granitoide; 7 — diabase; 8 — inferred fault; 9 — area of reconnoitered deposit

Wycinek mapy geologicznej obszaru Myszkowa bez utworów kenozoiku, mezozoiku i permu
1 — ordowik-sylur dolny; 2 — sylur górny; 3 — dewon; 4 — karbon dolny; 5 — porfir; 6 — granitoid; 7 — diabaz; 8 — uskok przypuszczalny; 9 — obszar udokumentowanego złoża

COVER STAGE

The cover stage includes mainly Triassic, locally Lower Jurassic (Liassic) and Quaternary rocks. In the northeasterly direction this stage also includes Jurassic and Cretaceous rocks.

The Triassic and Lower Jurassic sequences are mainly represented by marine carbonate sediments of the Upper Buntsandstein and Muschelkalk, and terrigenous sediments of the Rhaetic and Liassic. In the vicinity of Myszków these rocks dip slightly monoclinally to the northeast. They are cut by faults of small amplitude (as much as tens metres).

VARISCAN STAGE

The Variscan stage includes Devonian and Lower Carboniferous sequences.

The Devonian rocks identified in the area are composed of two lithologic complexes:

— the lower complex is represented by clastic Emsian deposits discordantly overlying different Silurian members. These series are made of claystones and siltstones which are dark grey, in places grey-green, and pass upward into red siltstones with quartzitic sandstone interbeds. The total thickness is changeable ranging from several through tens of metres;

— the upper complex is represented by Eifelian, Givetian, Frasnian and Famennian rocks. In the lower portion they mainly consist of dark grey dolomite series interbedded by dolomitic marls and siltstones, whereas in the upper portion they are composed of light and dark grey, organodetrital, nodular and pelitic limestones with interbeds of variegated dolomites and siltstones. The total thickness of this complex is about 1000–1500 m.

Lower Carboniferous rocks in the neighbourhood of Myszków are developed primarily as the Culmian facies. Lithologically these are alternating dark grey claystones and

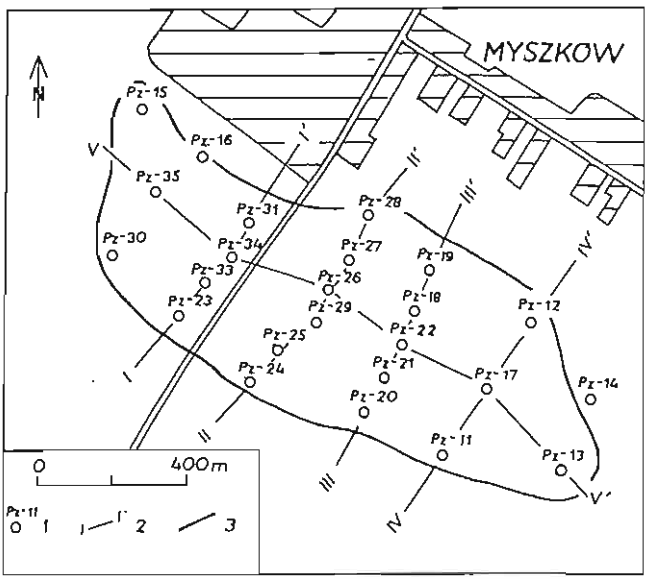


Fig. 2. Sketch map of the Myszków area
1 — borehole; 2 — cross-section line; 3 — area of reconnoitered deposit
Szkic sytuacyjny okolic Myszkowa
1 — otwór wiertniczy; 2 — linia przekroju; 3 — obszar udokumentowanego złoża

siltstones, and grey inequigranular sandstones. Their thickness is not well known. Some of them are preserved in synclinal depressions.

CALEDONIAN STAGE

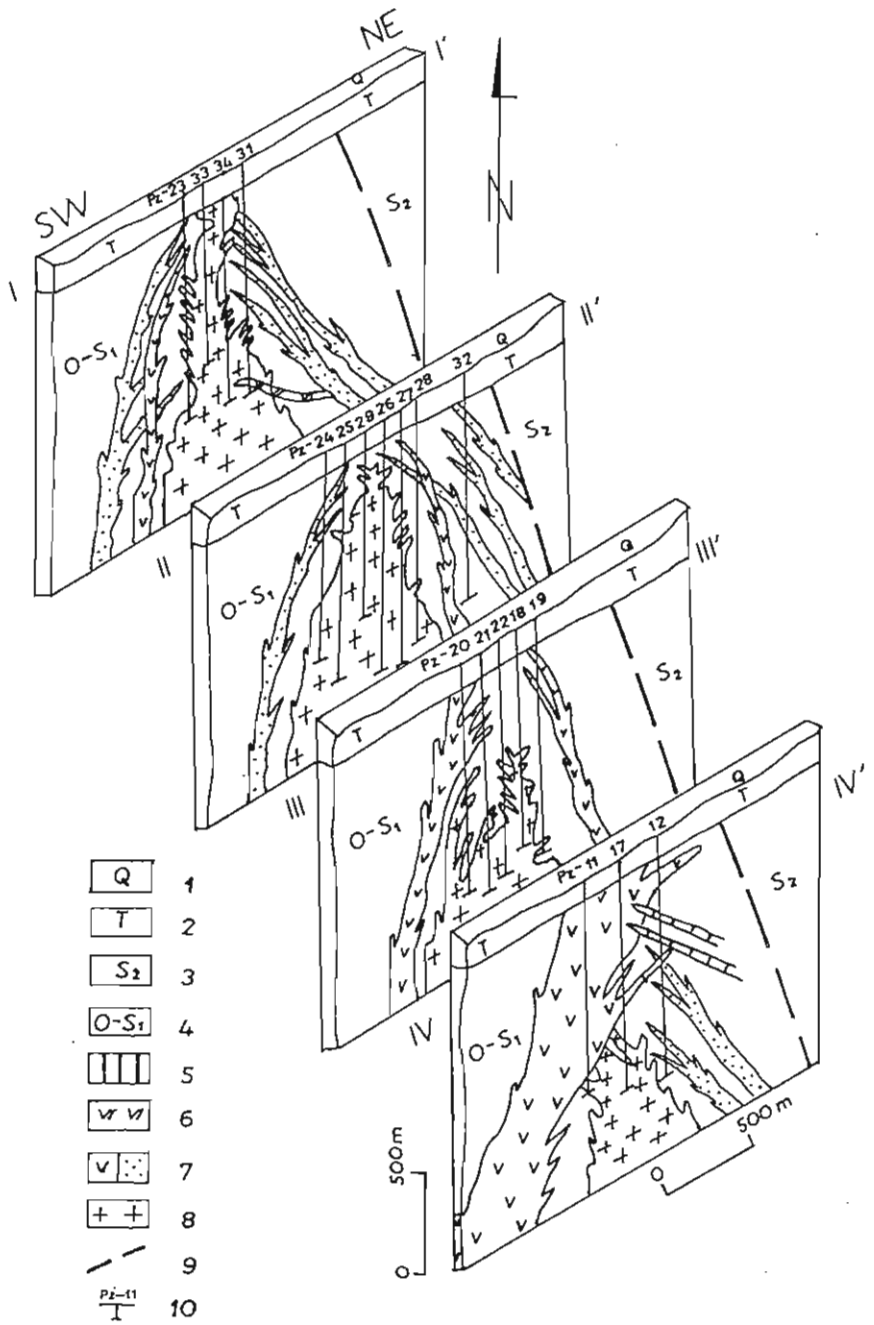
This stage is composed primarily of Early Palaeozoic geosynclinal metamorphosed rocks. Two principal lithogenic complexes can be distinguished within these sequences:

— the lower is represented by Cambrian through Lower Ludlow rocks corresponding to the early evolutionary phase of the Caledonian geosyncline;

— the upper consists of Middle and Upper Ludlow rocks corresponding to the middle phase of the Caledonian geosyncline.

Within the lower complex, there occur mainly dark grey, black or grey-green meta-pelites and meta-aleurites with interbeds of grey, fine-grained meta-greywackes and intercalations of lydites and siliceous shales. The Ordovician formations contain carbonate rocks chiefly in the form of marbled and skarned limestones. The rocks described reveal higher degree of metamorphic alterations compared to those assigned to the upper complex. In addition, they are often cataclased and tectonically polished, as well as affected by the process of feldspar metasomatism. The total thickness of this complex has not been determined yet. It is estimated to be more than 6 km.

The upper eomplex, probably of Middle and Late Ludlow age, consists of flysch formation rocks. They comprise an alternating series of grey, grey-green, and locally red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shales and greywackes. In its upper part there appear polymictic conglomerates, whereas in the lower part, interbeds of altered volcanites of keratophyre type occur. These rocks are folded and slightly affected by regional metamorphism. Petrographically, they are mainly represented by chlorite-sericite phyllites. The total thickness of the upper complex is also great, presumably more than 4.5 km.

The total thickness of these two complexes is estimated to be over 10 km. Their share in the structure of the Palaeozoic basement the area is depicted by Figures 1 and 3.

TECTONICS AND MAGMATISM

The main tectonic element distinguished within the framework of the Palaeozoic basement is the Caledonian-Variscan elevational structure of Myszków (K. Piekarski, 1983; K. Piekarski, Z. Migaszewski, 1993). The core of this structure is mainly composed of metamorphosed series of the lower Caledonian complex. The core of these beds extends in the NW–SE direction over an area 12 km long and 3–5 km wide. Outside, they are covered by flysch rocks of the upper Caledonian complex. Devonian rocks occur primarily on its southern, western and northern flanks. As a result of the Variscan movements, the structure described was block-faulted. During the erosion period spanning the Upper Carboniferous to the Lower Triassic, Lower Carboniferous, Devonian and most late Early Palaeozoic sediments were stripped. The erosion base level reached Middle Ordovician or perhaps even Cambrian strata.

The Mesozoic cover overlying Early Palaeozoic rocks prevents determination of their exact stratigraphic position. In the borehole, only the presence of the Silurian and Ordovician formations has so far been faunally documented.

In the whole Palaeozoic, especially during the Caledonian orogenic movements, the area underwent intensive magmatic activity. Within the metamorphosed Lower Palaeozoic formations many intrusive bodies of granodiorite, rhyolite, dacite, locally diabase, keratophyre, trachyandesite and lamprophyre type were identified (O. Juskowiak *et al.*, 1978; M. Muszyński, 1991).

The Myszków deposit is represented primarily by stockwork molybdenum, tungsten, and copper ores. It is located in the middle part of the elevational structure of Myszków that may have been formed as a result of tectonic squeezing and uplifting.

Fig. 3. Cross-sections through the Myszków deposit area (location in Fig.2)
1 — Quaternary; 2 — Triassic; 3 — Upper Silurian; 4 — Ordovician-Lower Silurian; 5 — lamprophyre; 6 — trachyandesite; 7 — quartz porphyry and porphyry with small quartz content; 8 — granitoide; 9 — inferred fault; 10 — borehole

Przekroje geologiczne z obszaru złoża Myszków (lokalizacja na fig. 2)
1 — czwartorzęd; 2 — trias; 3 — sylur górny; 4 — ordowik-sylur dolny; 5 — lamprofir; 6 — trachyandezyt; 7 — porfir kwarcowy i porfir z małą ilością kwarcu; 8 — granitoid; 9 — uskok przypuszczalny; 10 — otwór wiertniczy

ORE MINERALIZATION CHARACTERISTICS OF THE MYSZKÓW DEPOSIT

The Myszków deposit reveals polygenetic character. Aside from the stockwork type, other genetic types of ore mineralization, i.e., sedimentary, metamorphic, magmatic and hydrothermal are also present here. This diversity of the ore mineralization processes taking part in formation of the Myszków deposit has been manifested by the presence of rich ore mineral association.

In the Myszków deposit, the following ore minerals have been identified: pyrite, pyrrhotine, marcasite, chalcopyrite, bornite, chalcosine, cubanite, covellite, molybdenite, sphalerite, galena, arsenopyrite, tenantite, tetrahedrite, aikinite, bismuthinite, native bismuth, galenobismuthinite, cosalite, emplectite, bismuth and silver sulphurtellurides, anglesite, and among oxide minerals — titanium oxides (anatase and rutile), magnetite, hematite, ilmenite, scheelite, wolframite and cassiterite. Among the aforementioned minerals the most important with respect to amount and practical application are: molybdenite, scheelite, chalcopyrite, pyrite, magnetite, sphalerite and galena. They occur in the form of several generations featured by different structures and textures. The association of accompanying minerals includes: quartz, chalcedony, feldspars (microcline, adular, albite), chlorite, muscovite, biotite, epidote, actinolite, barite, fluorite, calcite, ankerite, celestine, gypsum, kaolinite and dickite.

The aforementioned ore minerals make up several genetically diversified ore formations and less important paragenetic associations, which were formed in different periods of time as a result of the influence of various mineralization processes (sedimentary, metamorphic and hydrothermal). The most interesting are particularly three formations:

— pyrite-copper of sedimentary or sedimentary-exhalative type,

— molybdenum-tungsten-copper of stockwork type,

— copper of porphyry copper type.

The pyrite-copper formation, originally of sedimentary or sedimentary-exhalative provenance, is the oldest mineralization making up the Myszków deposit. Its main minerals are pyrite and chalcopyrite, in subordinate amounts bornite, sphalerite, galena, molybdenite, arsenopyrite, wolframite and admixtures of gold. This formation reveals a connection with a series of dark or almost black meta-shales formed in a low-energy, reducing sedimentary environment. Zones of this type of ore mineralization appear fairly commonly in Ordovician and Lower Silurian rocks constituting the cover of the granitoid stock — the main geologic element of the deposit discussed (Fig. 3).

Within the dark grey and black Ordovician and Silurian meta-shales, two principal textural types of pyrite-chalcopyrite mineralization, i.e., impregnative-veined and massive, can be distinguished. Previous investigations indicate that the first type of mineralization is widely spread and dominates the area. This was confirmed in many borehole sections surrounding the Myszków deposit (Pz-12, Pz-16, Pz-19, Pz-23, Pz-24, Pz-25, Pz-27 and Pz-28 — Figs. 1, 2).

During regional and thermal metamorphism the ore minerals of this formation underwent partial recrystallization combined with their remobilization and transformation. As a result of these processes, chlorite-quartz veins were formed; they are metasomatic, boudinaged and primarily contain an admixture of pyrite and chalcopyrite commonly accompanied by new minerals such as pyrrhotine and magnetite. The processes of regional and thermal

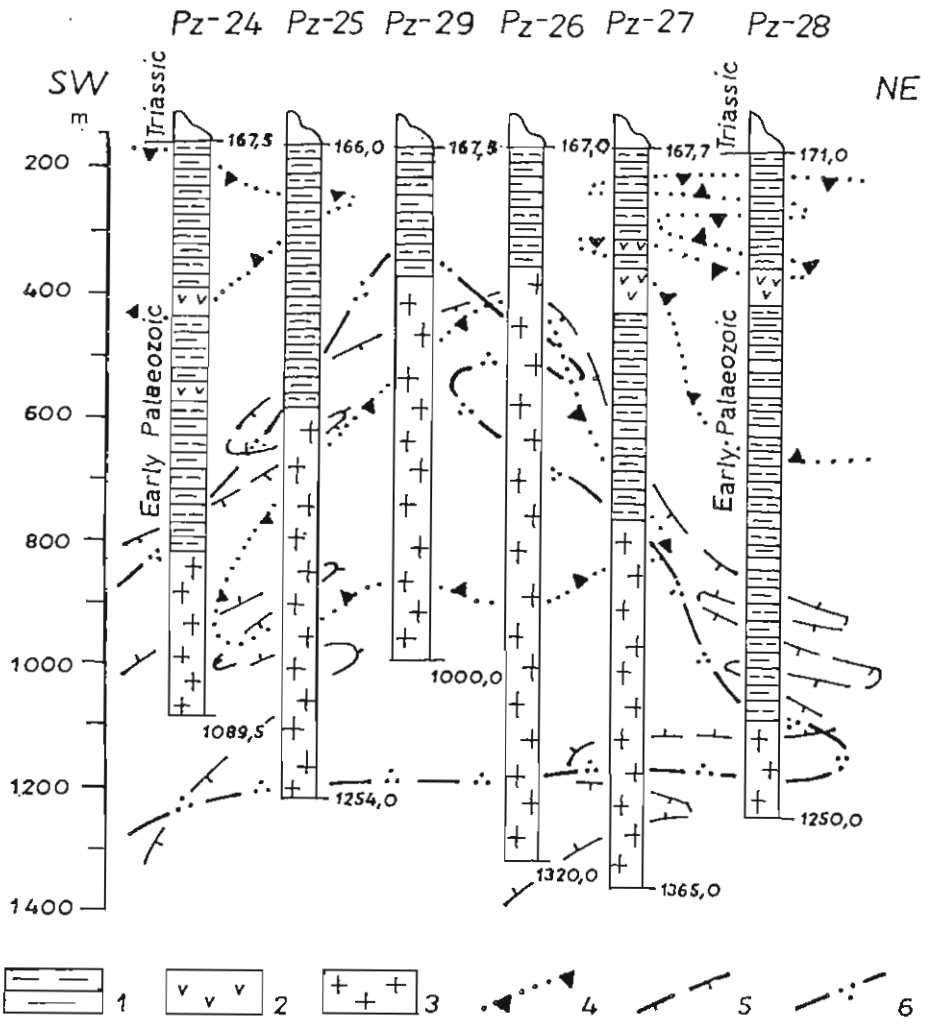


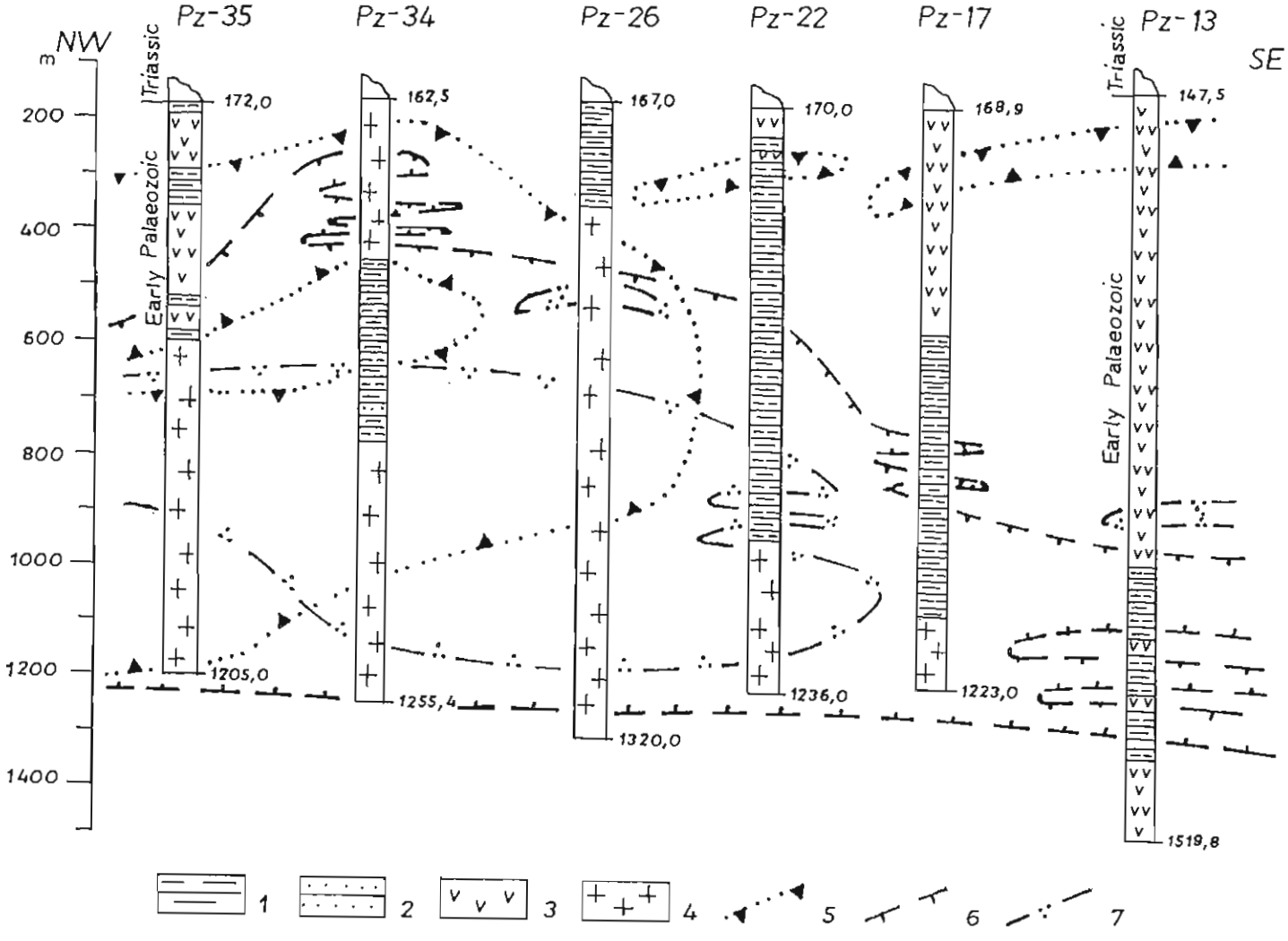
Fig. 4. Distribution of Cu, Mo and W polymetallic mineralization in the transverse cross-section II–II' (location in Fig. 2) through the Myszków deposit

1 — metamorphic schist; 2 — porphyry; 3 — granitoide; 4 — extent of mineralization — more than 0.2% Cu; 5 — extent of mineralization — more than 0.06% Mo; 6 — extent of mineralization — more than 0.06% W

Rozkład mineralizacji polimetalicznej Cu, Mo i W w przekroju poprzecznym II–II' (lokalizacja na fig. 2) złoża Myszków

1 — łupek metamorficzny; 2 — porfir; 3 — granitoid; 4 — zasięg mineralizacji Cu > 0,2%; 5 — zasięg mineralizacji Mo > 0,06%; 6 — zasięg mineralizacji W > 0,06%

metamorphism must have had an impact on forming skarns and skarnoids of infiltration type occurring locally within meta-shale series enriched in carbonates. The processes mentioned above did not cause major redistribution of ore mineralization in laterally neighbouring rocks. The copper content within the zones embraced by remobilization


NW
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200
400
600
800
1000
1200
1400
Pz-35
Pz-34
Pz-26
Pz-22
Pz-17
Pz-13
Triassic
Early Palaeozoic
172,0
1205,0
162,5
1255,4
167,0
1320,0
170,0
1236,0
168,9
1223,0
147,5
1519,8
1
2
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processes is commonly higher than that in the zones containing original pyrite-chalcopyrite mineralization. At some places it reaches 4.7% (borehole Pz-28). In the aforementioned borehole, the zone of pyrite-copper mineralization reached greatest thickness — hundreds of metres, largely due to the super position of younger veined mineralization with an admixture of pyrite and chalcopyrite of stockwork type on syngenetic and metamorphic mineralization.

The molybdenum-tungsten-copper formation of stockwork type is of basic importance for ore mineralization of the Myszków deposit. It is linked to quartz and quartz-feldspar vugs and veins of several generations. They dip at various angles (20–80°) and their thickness ranges from I mm to 2 cm, sporadically to 2 m. The prineipal ore minerals of this formation are molybdenite, scheelite, chalcopyrite, pyrite, scarcely bornite, sphalerite, galena, cubanite, aikinite, rutile, magnetite and wolframite.

This formation is imposed primarily on the intensively tectonically disturbed and hydrothermally altered granitoid stock, as well as on metamorphic rocks making up the stock's cover, and piercing dikes of older poor- and non-quartz porphyries (dacites). The stock, extending NW–SE, was traced by borings at a distance of 1200 m. In its apical part it narrows fast and splits into thinner branches passing into small apophyses and veinlets — in places reaching a few centimetres in thickness. Downward, it probably passes gradually into a larger igneous body constituting the core of the Myszków elevational structure. The setting of the granitoid stock is illustrated by geologic cross-sections (Fig. 3).

The third of the principal ore formations present within the Myszków deposit is the copper formation of porphyry copper type. It is connected with quartz porphyries (rhyolites) forming thick intrusive bodies on both flanks of the granitoid stock (boreholes Pz-11, Pz-13, Pz-14, Pz-17, Pz-20 and Pz-30). The quartz porphyry intrusions formed after the main stockwork mineralization. This is proved by xenoliths of metamorphic schists, and granitoids with stockwork mineralization incorporated in the quartz porphyries (borehole Pz-13).

The porphyries feature original mineralization represented by tiny grains of pyrite, chalcopyrite and sporadically molybdenite scattered within the rocky groundmass. The copper content in unaltered portions comprising impregnative mineralization ranges from 0.05 to 0.15%, exceptionally reaching 0.7% (borehole Pz-20). Within the portions of hydrothermally-altered porphyries as a result of local remobilization, there appear veined and nested concentrations of ore minerals formed of massive chalcopyrite, commonly with dark quartz, and chlorite, infilling fissures and empty voids. They are usually several metres thick, and they do not form larger, regular ore zones. The copper content is very variable, in places reaching even 1.5%. This mineralization is not associated with cementation zones

Fig. 5. Distribution of Cu, Mo and W polymetallic mineralization in the longitudinal cross-section V–V' (location in Fig. 2) through the Myszków deposit

1 — metamorphic schist; 2 — greywacke; 3 — porphyry; 4 — granitoide; 5 — extent of mineralization — more than 0.2% Cu; 6 — extent of mineralization — more than 0.06% Mo; 7 — extent of mineralization — more than 0.06% W

Rozkład mineralizacji polimetalicznej Cu, Mo i W w przekroju podłużnym V–V' (lokalizacja na fig. 2) złoża Myszków

1 — łupek metamorficzny; 2 — szarogłaz; 3 — porfir; 4 — granitoid; 5 — zasięg mineralizacji Cu > 0,2%; 6 — zasięg mineralizacji Mo > 0,06%; 7 — zasięg mineralizacji W > 0,06%

enriched in chalcosine, which is characteristic of the porphyry copper deposits in other countries.

ORE ZONATION

Certain original zonation occurs in the spatial distribution of the ore mineralization within the Myszków deposit. It concerns primarily the mineralization represented by the molybdenum-tungsten-copper formation of stockwork type. As for the spatial distribution, the remaining two formations, i.e., pyrite-copper (of sedimentary provenance) and copper of porphyry copper type, do not reveal, aside from the quantitative variation, differentiation in their mineral composition. To better illustrate and describe this problem, several transverse and longitudinal cross-sections, including the zones of molybdenum, tungsten and copper mineralization, were made. Two principal cross-sections of the deposit discussed are presented in Figures 4 and 5.

The analysis of these cross-sections shows that in the ore mineralization of the Myszków deposit both horizontal and vertical zonation is distinctly marked. In the middle portions of the granitoid stock the main ore minerals ascribed to the quartz and quartz-feldspar veins of stockwork type are molybdenite, scheelite and chalcopyrite, whereas toward its periphery (along NW–SE extent) a drop in the scheelite and chalcopyrite content (molybdenite remains the main mineral) is noted. In the transverse direction (NE–SW), the extent of abundant scheelite mineralization is confined to the granitoid body and its nearest exocontacts. In the zones of the cover rocks adjacent to the intrusion, distinct enrichment of the stockwork veins in molybdenite and, in outer portions, chalcopyrite, is observed.

In the vertical cross-sections it is noted that the upper portions of the granitoids are commonly enriched in chalcopyrite, whereas the deeper ores in molybdenite and scheelite.

In the cover rocks of the granitoid, the concentration of chalcopyrite mineralization is observed on both flanks of the stock. This mineralization commonly overlaps the pyrite-copper mineralization of sedimentary or sedimentary-exhalative provenance forming rich zones of copper mineralization in some places (boreholes Pz-12 and Pz-28). They are associated by local anomalous admixtures of molybdenite and wolframite reaching 0.10% W (borehole Pz-12), or scheelite — up to 0.13% W (borehole Pz-22). Within the stockwork veinlets, increase of molybdenite and depletion in chalcopyrite is observed with depth.

A low zinc-lead mineralization of hydrothermal origin, not revealing any spatial relationship with the aforementioned ore formations, was identified within the Myszków deposit. The mineralization described occurs separately in the zones of younger tectonic movements of Mesozoic age within stratigraphically-diversified rock series assigned to the Lower Palaeozoic through Permian. Its spatial extent steps considerably over the north-eastern margin of the Upper Silesian Coal Basin. The source of this mineralization seems to have been rooted in Triassic rocks.

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BUDOWA GEOLOGICZNA I CHARAKTERYSTYKA OKRUSZCOWANIA ZŁOŻA MYSZKÓW

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

Polimetaliczne złoże Myszków zostało odkryte i rozpoznane w latach 1982–1990. Położone jest ono w północno-wschodniej części Wyżyny Krakowsko-Częstochowskiej. Obszar ten zbudowany jest z monoklinalnie zalegających utworów mezozoicznych, tworzących piętro pokrywowe. Występujące w ich podłożu utwory paleozoiczne należą do dwóch pięter strukturalnych: kaledońskiego i waryscyjskiego.

Piętro kaledońskie budują przeważnie zmetamorfizowane i sfaldowane utwory kambru, ordowiku i syluru. Piętro waryscyjskie tworzą lekko sfaldowane i zblokowane utwory dewonu i dolnego karbonu.

Głównym elementem paleozoicznego podłoża w obszarze omawianego złoża jest kaledońsko-waryscyjska elewacyjna struktura Myszkowa. Jej staropaleozoiczne jądro rozciąga się w kierunku NW–SE na przestrzeni około 12 km, w pasie szerokości 3–5 km. Centralna część tej struktury zbudowana jest prawdopodobnie z utworów ordowiku i dolnego syluru, wykształconych głównie w postaci zmetamorfizowanych (w facji zieleńcowej) osadów ilasto-mułowcowo-piaszczystych, z częstymi przeławiceniami (głównie w ordowiku) skał węglanowych, o łącznej miąższości ponad 10 km.

W obrębie zmetamorfizowanych utworów staropalcozoicznych pojawiają się większe ciała intruzywne typu: granodiorytów, porfirów kwarcowych (ryolitów), oraz lokalnie niewielkie dajki porfirów bezkwarcowych (dacytów), diabazów, keratofirów, trachyandezytów i lamprofirów.

W części środkowej elewacyjnej struktury, w miejscu jej największego wyniesienia, znajduje się złoże Myszków. W jego budowie bierze udział kilka różnych pod względem genetycznym formacji kruszcowych, wśród których najważniejszymi są: molibdenowo-wolframowo-miedziowa typu sztokwerkowego, pirytowo-miedziowa pochodzenia osadowego i miedziowa typu porfirowego.

Obserwowana pewna strefowość, w przestrzennym rozmieszczeniu okruszcowania złoża Myszków, dotyczy głównie mineralizacji reprezentującej formację molibdenowo-wolframowo-miedziową typu sztokwerkowego. Strefowość tę zilustrowano na dwóch przekrojach: poprzecznym i podłużnym z naniesionymi zasięgami mineralizacji molibdenowej, wolframowej i miedziowej (fig. 4 i 5).

Stwierdzane w obrębie złoża Myszków ubogie przejawy mineralizacji cynkowo-ołowiowej pochodzenia hydrotermalnego nie mają związku przestrzennego z wyżej przedstawionymi formacjami rudnymi. Źródłem tej mineralizacji są prawdopodobnie utwory triasu.