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Geological criteria defining mineral deposit

Key words

Mineral deposits, resources, cut off parameters

Abstract

Mineral deposit is commonly defined as natural accumulation of mineral commodity that can be economically mined. The existing classification of resources and reserves as for example United Nations Framework Classification (UNFCR) or JORC Code have adopted the uniform definitions of particular their categories, but do not touch the problem how the mineral deposit itself is defined. If global estimates of resources are composed or comparisons, made the criteria defining mineral deposits and their resources and reserves should be simultaneously presented to avoid miscomparisson of not comparable items. The criteria defining mineral deposit and its resorces commonly used are:

— the greatest depth of location (or the greatest allowable stripping ration if deposit is located close to the surface, suitable for opencast mining),

— cut off values of mineral quality parameters,

— the lowest acceptable deposit thickness,

— the lowest acceptable mineral accumulation, defined as amount of mineral per square meter surface.

There are no natural values of such criteria that can be used for delineation of the mineral deposit and they should be arbitrally selected. At opportunity study stage, threefold approach can be proposed for finding them:

1) based on analogy, considering the data from existing mines and mining projects,

2) based on rough economic estimates considering reported costs and values of mineral commodities,

3) based on general data on applicable mining and mineral processing technology standards considering mining safety rules and marketable mineral quality standards.

Such mode of defining mineral deposit and its resources is ilustrated by copper ore deposit example.

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1. The problem

Mineral deposit is commonly defined as natural accumulation of mineral commodity that can be economically mined. The concept of natural accumulation and technical mineability is generally accepted deposit feature. However economic mineability is a matter of discussion. Most often it is defined as the mineability at a profit. Sometimes it encompasses the broader sense of general economic value of deposit as a source of raw material, necessary for country economy: economic security of domestic industry, the possibility to generate labor through mining or through general activization of local economy. The real problem pose the mineral accumulations inaccessible at present, encountered in remote, difficult geographical conditions (e.g. in desertic, heavy forested or polar areas), or located in the areas of protected landscape (as national parks etc. for example). They can have all natural features making them technically mineable, but the economic mineability cannot be testified. The UN Economic and Social Commission proposed in such a case to neglect the economic mineability and use the term "mineral deposit" for all natural mineral accumulations that can be technically mineable (Mineral Resources... 1970). The problem is not so simple however because "technical mineability" encompass in hidden form the economic concept. It can be demonstrated that almost any mineral accumulation can be technically mineable, the cost being the only limit.

The globalization of mining activity poses the problem of uniform approach to reserve and resources evaluation. The UN proposal of framework classification of resources and reserves (United Nations Framework Classification of Resources/Reserves — UNFCR,) or JORC Code (1999) have adopted the uniform definitions of particular resources and reserves categories, but do not touch the problem how the mineral deposit itself is defined. The problem seems however important. If global estimates of resources are composed or comparisons, made the criteria defining mineral deposits and their resources and reserves should be simultaneously presented to avoid miscomparisson of not comparable items. The problem is not so obvious at a glance, however remarked long ago. At XII-th International Geological Congress in 1912 held in Toronto, for example, attempting to present world coal resources, there was not possible to present in uniform manner the coal resources of Upper Silesian coal basin, at those time divided between Austria, Germany and Russia, because of varied criteria defining them in particular countries (Table 1). The problem still exist if we have to compare the resources of any mineral commodity reported in various countries or mined by various companies, using their particular set of criteria defining the mineral deposit, such as the depth to which resources are evaluated, minimum accepted deposit thickness or boundary values of parameters characterizing mineral quality (as e.g. metal content in ore). For example the bituminous coal resources are evaluated in particular countries up to the depth ranging from 500—1800 and even 2000 m, and in seams which thickness starts from 0,3 to over 1 m (Fettweiss 1979). Varied resources delineation criteria are sometimes used in different regions of the same country as in Canada for example (Hughews et al. 1989).

The discussion on economic value of mineral deposit is mostly focused on reserves[1] as amount of mineral commodity that can be mined at a profit. To define them the set of cut off

[1] The terms "reserves" and "resources" are used according to the CIMM and JORC code classification systems.

TABLE 1

The criteria used for coal deposits evaluation in Upper Silesian Coal Basin in the year 1912 (Czarnocki 1935)

TABELA 1

Kryteria definiujące zasoby węgla kamiennego w Górnośląskim Zagłębiu Węglowym stosowane w 1912 r. (Czarnocki 1935)

Part of Basin	Parameters used		
	Maximum depth	Minimum coal seam thickness	Other
Western and Central after R. Michael and W. Quitzow	1000 m	0.3 and additionally 0.5 in paralic series, 1.0 in limnic series	
North Eastern after S. Czarnocki		0.6 m	Less 20% because of faulting and pillars
Eastern after W.E. Petrascheck	1200 m	0.3 m	less 20—45% because of faulting, pillars and other phenomena

values of deposit parameters (mostly grade, e.g. ore grade) are used, delineating the economically mineable portion of resources, at the moment of evaluation. The mode of their calculations is discussed by various authors. The different formula is used (Annels 1991; Methods... 1985). The most commonly reported approach, strongly economically oriented, presented by Lane (1988) is not however uniformly accepted and is criticized (Groupe de Reflexion.... 1991—1994). This controversy reflects different approach to the mode of defining mineable deposit and the use of economic criteria to define it. Because of such controversy the other terms are proposed as "pay limit" or "break even value", e.g. "break even cut off grade", as precisely reflecting their economic sense.

The discussion focused on reserve valuation put away the problem of resources delineation that is exposed to arbitrary oriented geologists decisions. However if resources may be converted to reserves the mode of resources delineation should be reasonable from the point of view of their further mineability.

The basic concept of proposed mode of resources delineation is based on assumption that resources are defined by geologist on results of exploratory work, previous to mining, when no exact data on mining technology that should be applied exist and no detailed economic calculations are performed. Reported resources are used for opportunity study of mining project. It looks therefore reasonable, that criteria used by geologist for mineral deposit delineation should, as far as, possible define its resources, that can be considered theoretically mineable. Then reserves, calculated on detailed technical and economic assumptions, can be delineated within the limits of initially reported resources and consist their economically mineable portion at the moment of evaluation, demonstrated by prefeasibility or feasibility study.

To avoid the unreasonably optimistic resources evaluation, the criteria used for defining them should be as far as possible close to one defining reserves, but delineating the larger volume of mineral commodity as mineral deposit (Fig. 1). Within the limits of such defined resources,

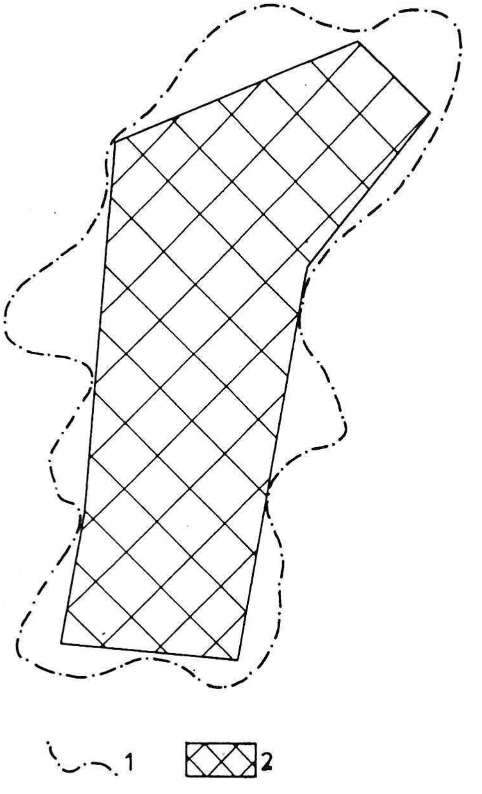

Fig. 1. Deposit resource and reserve boundaries (scheme)

Rys. 1. Granice zasobów geologicznych i przemysłowych (schemat)

mining engineer can delineate the feasible portion as deposit reserves. Broader resources limits allow free alternative choice of possible mining strategies and selection of the best one for mineral recovery at a profit. The mode of ore reserves delineation for open pit extraction proposed by Lechrs-Grossman (1965) method may be an example.

Such approach to mineral deposit delineation is well established in Poland and practically used since 50 years. As result of successful geological exploration the resources of mineral deposit are delineated by set of criteria unfortunately called "balance criteria". The term is used because the resources data are reported in governmental data file (resources balance report), summarized for every mineral commodity and corrected every year due to depletion by mining extraction and increase due to new discoveries.

2. The criteria used for delineation of mineral deposit

The mineral deposit as natural accumulation of mineral commodity is defined by its volume i.e. geometric features, mode of location underground and mineral quality making it utilizable.

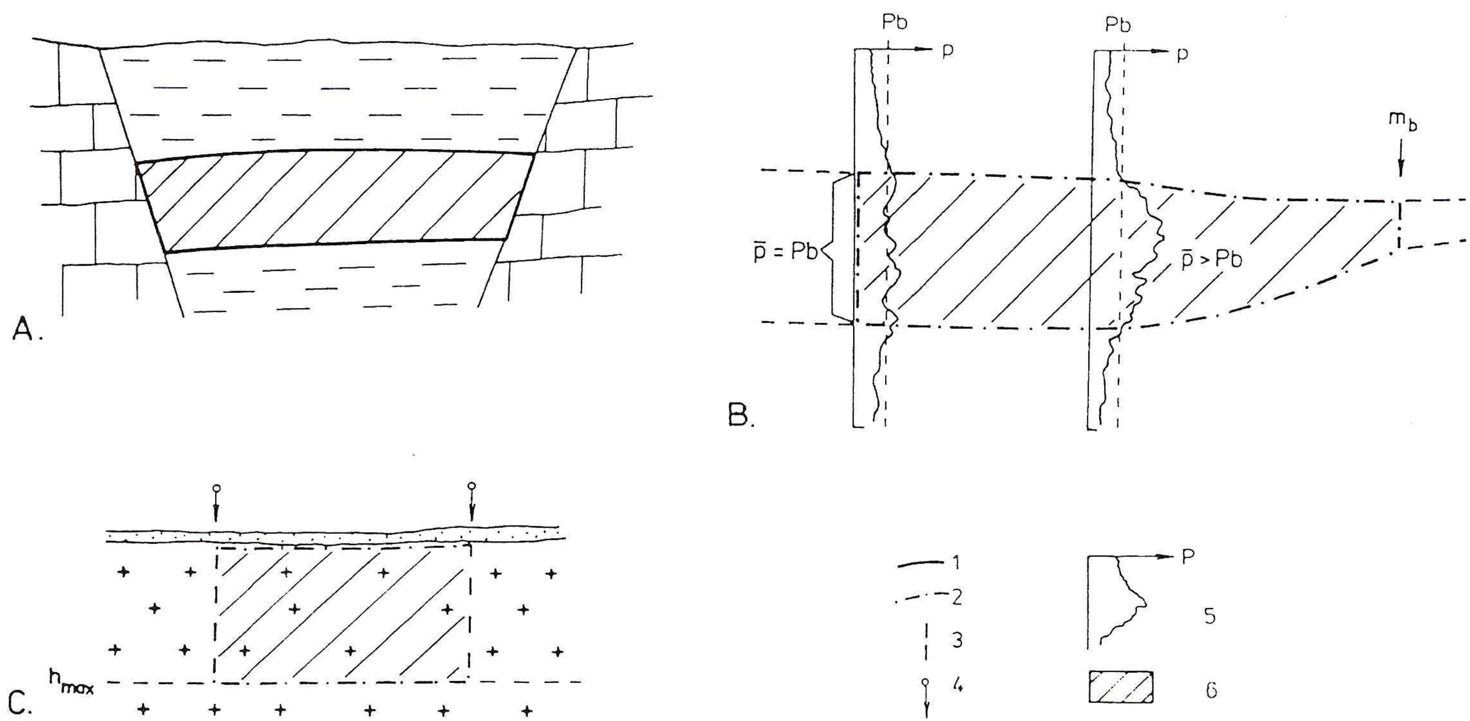

Fig. 2. Modes of deposit boundary delineation (schematic presentation)
A — natural boundaries (1), B — imposed boundaries (3), C — arbitrary selected (2), 4 — property boundary, 5 — variation of useful component (e.g. metal content) within the deposit profile, 6 — mineral deposit; p_b — cut off content of useful component, $\bar{p}$ — average content of useful component in vertical section of the deposit (within deposit profile), m_b — cut off deposit thickness, h_{max} — maximum depth of possible mining or quarrying

Rys. 2. Sposoby określania granic złóż kopalin stałych
A — granice naturalne, B — granice umowne, C —granice sztuczne; Granice: 1 —naturalne, 2 —umowne, 3 —sztuczne, 4 —granice własności gruntowej, 5 — wykres zawartości składnika użytecznego w profilu, 6 — złoże; p_b — zawartość brzeżna składnika użytecznego, $\bar{p}$ — zawartość średnia składnika użytecznego w profilu złoża, m_b — miąższość brzeżna złoża, h_{max} — maksymalna głębokość możliwej eksploatacji

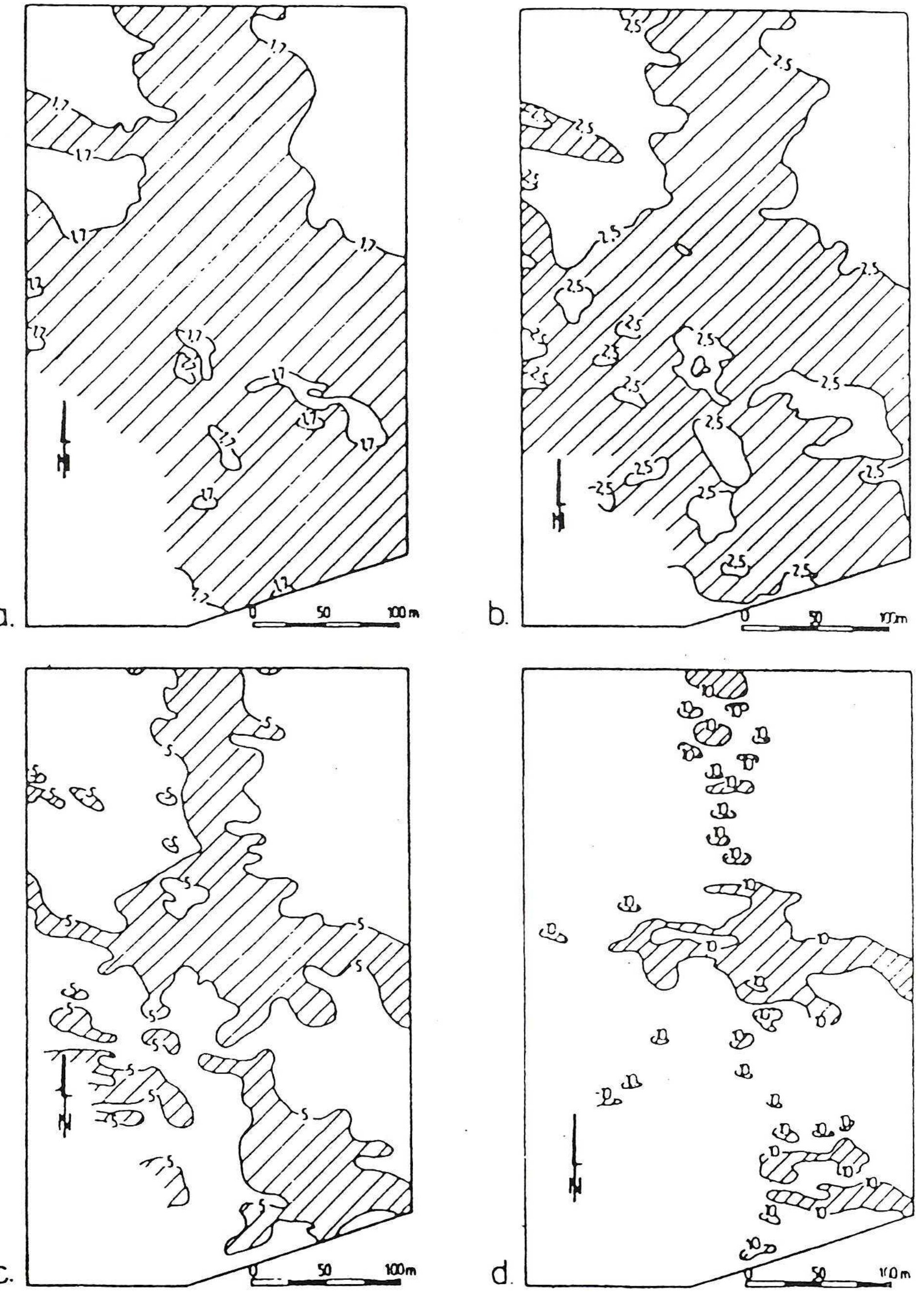

Fig. 3. Variation of deposit boundary position related to varied cut-off zinc content. Olkusz Zn-Pb ore deposit (after Blajda 1985)

Rys. 3. Zróżnicowanie granic złoża rud Zn-Pb w zależności od przyjętej brzeżnej zawartości cynku. Złoże „Olkusz" (wg Blajdy 1985)

This allows presenting the set of criteria defining mineral deposit. The basic, and the most commonly used are:

— the greatest depth of location (or the greatest allowable stripping ration if deposit is located close to the surface, suitable for opencast mining),

— values of mineral quality parameters (cut off values, varied in respect to kind of mineral deposit), the lowest ones in the case of useful components or properties, the greatest allowable in the case of deleterious or toxic elements or unwanted properties,

— the lowest acceptable deposit thickness,

— the lowest acceptable mineral accumulation, defined as amount of mineral per square meter surface.

There are no natural values of such criteria that can be used for delineation of the mineral deposit. It is well visible in the case of ore deposits if gradual change of metal content is observed from mineralized zone to surrounding rocks recognized barren (Fig. 2) or in the case of coal seam with decreasing thickness (thinning out) from few meters to few centimeters The mode of deposit delineation must be therefore arbitrally adopted. The mode of adoption is a crucial one because it may dramatically affect the deposit shape, location and its resources as presented on Fig. 3.

The deposit as a mineable body can be additionally delineated by property boundaries, boundaries of area licensed for exploration etc. Such cases are excluded from further discussion, focused only on delineation of mineral deposit by its natural features, and natural features of deposit environment.

3. Terminology problems

Almost all deposits are prospected and explored in stepwise manner. At any step of exploration the mineral deposit should be delineated as a body which value for further possible mining can be evaluated, motivating more advanced exploration and feasibility study. Three steps of deposit evaluation can be generally defined, adopted in UNFCR (UNFCR 1997):

— opportunity study based on geological knowledge of deposit and general idea of possible mining,

— prefeasibility study based on detailed geological knowledge of deposit and preliminary economic evaluation and layout of planned mining,

— feasibility study based on detailed knowledge of deposit and detailed estimation of its economic value.

The term "cut off value" (especially "cut off grade") is commonly used as minimum grade value (or minimum value of other parameters) defining deposit reserves (Annels 1991). Lane (1988) has strongly advocated for economically based calculations of cut off grade values. Such approach is however impossible at the geological exploration and opportunity study stage for resources delineation.

At the opportunity study stage it is indispensable to delineate mineral deposit as a body of mineral commodity which resources are supposed mineable. Within such limits the mining can be scheduled by mining engineer and the appropriate portion of deposit economically mineable selected, according to existing at the moment or forecasted economic and technical mining conditions.

At this stage the deposit delineation can be based on a set of cut off values of geological parameters, reasonably selected from economic and mining point of view, but in enough general manner, that allow further more precise delineation of mineable deposit and its reserves at prefeasibility or feasibility study stage. The cut off values used at opportunity study stage can be named "geological cut off values", or "geological criteria of deposit" to avoid misunderstanding with the one, which evaluation is based on detailed technical and economic data and considerations, and used for reserve calculation.

4. The mode of selection of geological criteria defining mineral deposit

The geological criteria delineating mineral deposit, presented above, should reasonably define the deposit resources as potentially mineable. Threefold approach can be proposed for finding them:

1. Based on analogy, considering the data from existing mines and mining projects.
2. Based on rough economic estimates considering reported costs and values of mineral commodities.
3. Based on general data on:

— applicable mining and mineral processing technology standards considering mining safety rules,

— marketable mineral quality standards.

These three approaches are not exclusive and can be simultaneously applied for evaluation of cut off values of particular deposit parameters. In any of the proposed approaches the statistical data are needed from currently active mines.

The method of selection of cut off values of parameters defining the deposit can be illustrated by copper deposits example.

Three criteria can be used to define the copper deposit as a presumed mineable geological body:

— maximum depth of location,

— minimum copper content in ore,

— minimum copper accumulation (amount of copper per square meter of deposit surface (product of copper content, deposit thickness and bulk density of the ore).

The mineral thickness is less applicable because of varied copper content in ore, which allow to mine the thin, but rich ore body, simultaneously with surrounding, not sufficiently mineralized or barren rock. Copper accumulation better describes ore value in such a case.

The depth of deposit location affects mostly the cost of mining. In underground mining it depends of length of vertical haulage, ventilation or climatization needed, dependent of geothermic gradient, possibilities of natural hazards (e.g. rock bursts) etc. It is difficult to calculate it precisely at geological study stage. The analogy to recently operating mines is the best mode of defining maximum depth to which deposit can be reasonably explored and its resources evaluated.

According to recently accessible data about 1200 m depth is most often the lowest one gained by underground copper or Ni-Cu mines and it can be considered as a limit of mineable Cu ore resources.

The evaluation of minimum copper content applicable for deposit delineation is more complicated, because of:

— different cut off values recently used in opencast and underground mining,

— need for both the cut off values defining the vertical and horizontal deposit boundary,

— existing strong relationship between cut off copper content and average one within the deposit or given part of deposit, as well as relationship between the both copper contents and quantity of evaluated resources.

The cut off values of metal content define the deposit, opposing it against the barren or presumed uneconomically mineralized rocks, the both in vertical and horizontal direction. In vertical direction the cut off values of metal content, which define the location of top and bottom of deposit, may be related to particular rock samples taken in exploration boreholes (Fig. 2). In horizontal direction the cut off value may be related to the average copper content within the deposit profile including barren or less mineralized interlayers.

The minimum copper content extractable from ore depends of energy needed (mostly in ore processing). This relationship (Fig. 4) does not allow selecting particular copper content value as reasonable cut off grade. It make however almost obvious that it should be between 0.3 to

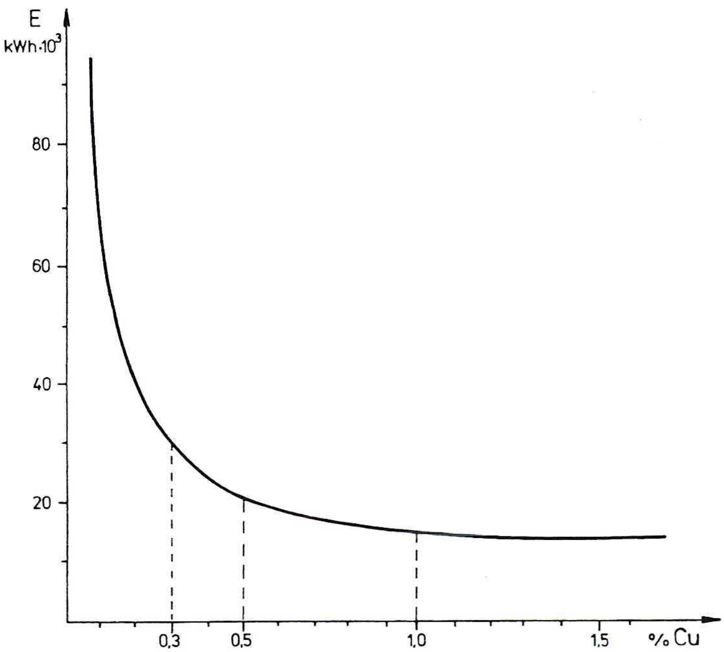

Fig. 4. Energy consumption for premetallurgical copper recovery in relation to copper content in ore (after Gentillhome 1983)

Rys. 4. Zużycie energii na odzysk miedzi w procesach przedhutniczych w zależności od zawartości miedzi w rudzie (wg Gentillhoma 1983)

1.0% Cu or close to 0.5%. The data from recently mined deposits demonstrate that the 0.5% Cu is the lowest commonly used cut off value, mostly in opencast mines. The lower one is applicable seldom, mostly in the case of copper accompanied by other metals as Mo or Au for example. The 0.5% Cu may be used as cut off grade delineating resources for open cast mining, and the cut off value between 0.5% and 1% Cu in the case of deeper seated ore deposits may be accepted considering Cu content variations in the zone of anticipated deposit boundary.

The other way of cut off copper content estimation is: cost (K) and value (C) comparison. The simplest mode is to relate anticipated cost of copper ore mining and copper recovery to the value of copper extracted. At the opportunity study stage only the operating cost may be considered and the profit neglected. Therefore:

$$K = \frac{p\eta C}{100}$$

and:

$$p = \frac{100K}{\eta C}$$

where:

p — cut off copper content,
K — cost of mining and processing of 1 ton (metric) of ore,
C — copper value (price),
η — copper recovery factor (in mining and processing).

The rough estimation of mining and enrichment costs could be based on the statistical data:
— taken by analogy from mines operating on similar deposits,
— suggested in USBM reports, presented by Camm (1991) or in mineral availability studies,
— evaluated through the statistical data on the net smelter return (NSR).

The copper value is more difficult to estimate because of strong temporary price variations. Various approaches can be used (Paulo, Krzak 1998). However, for deposit resources delineation, application of the average standarized price calculated on data from a period long enough, e.g. 20 years at least, is the simplest approach. In the case of strong price fluctuations the upper limit of possible variation of average price calculated at 95% confidence level may be suggested. That is:

$$C_{cf} = C_{av} + 2S_{av}$$

where:

C_{cf} — copper price evaluated for cut off grade calculation,
C_{av} — average copper price in given period (e.g. 20 years),
S_{av} — standard deviation of copper price for the same period.

The cut off value of copper accumulation (q) may be also calculated from the relationship between the cost of copper extraction in mining and processing, and the value of recovered copper:

$$C \cdot q \cdot h = K \cdot m \cdot \gamma_0$$

which gives after transformation:

$$q = \frac{K \cdot m \cdot \gamma_0}{c \cdot \eta}$$

where m is the mineable deposit thickness (or the heights of stope), γ_0 is the bulk density of ore.

In this formula three parameters should be arbitrary introduced: m, η and γ_0:

m — the minimum acceptable thickness as the lowest heights of mine workings currently applicable in mining, depending of the size of equipment used and safety conditions. The 1.5 m is the most common, but may be as less as 1 m in some cases,

η — copper recovery is compound parameter that encompasses both the copper ore extraction coefficient and the coefficient of copper recovery from the ore. It gains the value ~0.8 in the case of copper ore

γ_0 — the bulk density of ore may be measured or evaluated by analogy to the similar copper ores. If there is strong dependence of bulk density from ore mineralogy this parameter may be omitted in calculations and ore accumulation expressed as m.% (net mineral thickness if converted to decimal figures).

The same approach can be used for defining cut off values of deposit parameters of other ore deposits (Table 2). The statistical data on ore grade of various deposit models presented by Cox and Singer (1986), facilitate selection of cut off grade values close to minimum one reported for given deposit type (model).

TABLE 2

Criteria used for hard (bituminous) coal resources evaluation in different countries

TABELA 2

Kryteria stosowane w różnych krajach do oszacowania zasobów węgla kamiennego

Country	Maximum depth [m]	Minimum coal thickness [m]	Minimum calorific value [MJ/kg]	Maximum total sulphur content [%]
Poland	1000	1 (0.6**)	15 (12.5**)	2
Canada[1]	300—600 * (600—1 500**)	0.6—1.0 * (0.45—0.75**)	19.3 daf up to 50% ash	
USA[2]	1 800 (300***)	0.75 (1.5***)	33% ash	
CIS	1 800	0.5—1.0**	25—40% ash **	

* Related to the complexity of deposit structure.
** Future interest ("subeconomic").
*** Reserve base.
[1] Hughews et. al. 1989; [2] Wood et al. 1983.

For other non-metallic mineral commodities or industrial rocks the parameters that define the deposit may be different, but the mode of selection of their cut off values can be similar. For example the bituminous steam coal deposits may be defined by:

— maximum depth,
— minimum coal thickness in seam,
— minimum calorific value of coal in seam (including barren interlayers),
— maximum acceptable sulphur content.

In the case of metallurgical coal the maximum ash content in washed coal, as demanded by customers, is applied instead of calorific value.

The maximum depth and the minimum coal thickness may be accepted by analogy to the extreme of their values achieved in recently operating mines, the calorific value and sulfur content according to power plant technical exigencies.

In the case of industrial rock deposits the geological criteria used for their delineation may be only but few. The maximum overburden thickness or allowable stripping ratio and the lowest values of parameters defining the rock quality may be sufficient (Table 4).

In any case the final decision as to the cut of parameters accepted for deposit delineation and resources evaluation is arbitrary one, but the presented modes of estimation of their values can limit their choice options, sometimes unreasonable from the technical or economic point of view.

The deposit delineation is often constrained by the limits of the area allowed for exploration (licensed or owned), but still within such area the mineral accumulation should present the features making them intrinsically mineable.

The presented mode of cut off values calculation considers present technical and economic mining conditions. The calculated cut off values defines the deposit supposed economic at present. It may be doubtful if they can be valid in the future with changing progressively mining technology and economy. In such a case it can be recommended to calculate the other set of cut off values less rigorous, defining broader deposit volume supposed subeconomic at the moment but hoped to become economic and technically feasible in the future.

Such cut off values can be calculated using lower cost of mineral recovery, higher mineral prices, or considering the analogy of deposits mined in extreme conditions (e.g. lowest depth, lowest mineral thickness, lowest mineral grade etc.). The cost lower by 30 to 50% to currently reported or prices greater by 30—50% are sometimes suggested for such calculations. It is based on believe, that the need for mineral commodities and technical progress in mining and processing, will make mineable resources, recently considered uneconomic. Such believes and the mienability of subeconomic resources is however seldom confirmed (Gentillhomme 1983; Skinner 1979). The subeconomic resources should be therefore evaluated with caution and if evaluated the both presumed economic and subeconomic resources should be considered intrinsically mineable as proposed in UNFCR, subdivided to supposed economic and subeconomic if necessary and reasonably argumented, i.e. if enough data for their separation exist.

Because mineral deposit resources can be delineated by different sets of cut off parameters the values of this parameters should be presented in any case of resources calculations to avoid miscomparisson or summation of not comparable resources items.

TABLE 3

Cut off parameters used in Poland for delineation of ore resources

TABELA 3

Brzeżne wartości parametrów złoża przyjmowane dla okonturowania i obliczenia zasobów złóż rud (kryteria bilansowości)

Parameter	Stratabound Cu-Ag		Stratabound (MV type) Zn-Pb		Native sulphur	
	supposed economic	sub-economic	supposed economic	sub-economic	supposed economic	sub-economic
Maximum depth [m]	1250	1500	500		400	
Minimum useful component content [%]	0.7*	0.5*	2**	2***	10	5
Maximum ratio of oxidized to not oxidized metal content [%]			35			
Minimum useful components accumulation	50* [kg/m^2]	35* [kg/m^2]	7** [m.%]	5*** [m.%]	150 [m.%]	55 [m.%]

* Equivalent copper content: Cu_e = Cu [%] + 0.01 Ag [g/t].
** Zn+Pb content in sulphides only.
*** Zn+Pb content in all mineralogical forms.

TABLE 4

Cut off parameters used in Poland for delineation of industrial rock resources

TABELA 4

Brzeżne wartości parametrów złoża przyjmowane w Polsce dla okonturowania i obliczenia zasobów złóż kopalin skalnych (kryteria bilansowości)

Parameter	Limestone for lime production	Dimension stones	Crushed stones for road construction	Brick clay	Ceramic, refractory clays
Maximum overburden thickness [m]	15				
Maximum depth [m]	70	depth of possible quarrying			200*
Minimum deposit thickness [m]				2	2
Maximum stripping ratio	0.3	0.5	0.2	0.5	2**
$CaCO_3$ content [%]	>90		<90		<2
Minimum content of clay minerals %					40
Maximum content of marl grains over 0.5 mm				0.4	
Block recoverability [%]		marble — 5 granite — 20 sandstone — 20			
Compressive strength [MPa]			80		
Los Angeles [%]			35		
Maximum % of barren interlayers			30		
Minimum contraction coefficient [%]				6	

* Underground mining only.
** Opencast mining only.

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MAREK NIEĆ

KRYTERIA GEOLOGICZNE DEFINIUJĄCE ZŁOŻE KOPALINY

Słowa kluczowe

Złoża kopalin, zasoby, parametry brzeżne

Streszczenie

Złoże kopaliny jest definiowane jako naturalne jej nagromadzenie, które może być przedmiotem gospodarczo uzasadnionej eksploatacji. W istniejących klasyfikacjach zasobów, jak na przykład Międzynarodowej Ramowej Klasyfikacji Zasobów ONZ (UNFCR) lub w JORC-code, przyjęto jednolity system definiowania poszczególnych ich kategorii. Nie rozwiązano jednak problemu, jak samo złoże kopaliny ma być określane. W przypadku gdy mają być przedstawiane globalne oceny wielkości zasobów bądź porównywane zasoby różnych złóż lub w różnych krajach, powinny być równocześnie przedstawiane kryteria definiujące złoża i ich zasoby, by uniknąć zestawiania nieporównywalnych wielkości. Powszechnie używanymi kryteriami definiującymi złoża i ich zasoby są:

— maksymalna głębokość położenia złoża (lub największy dopuszczalny stosunek grubości nadkładu do miąższości złoża w przypadku złóż eksploatowanych odkrywkowo),

— minimalna akceptowalna miąższość złoża,

— brzeżne wartości parametrów charakteryzujących jakość kopaliny,

— minimalna zasobność złoża, definiowana jako ilość kopaliny na 1 m^2 powierzchni złoża.

Liczbowe wartości tych kryteriów nie wynikają z naturalnych właściwości złoża i musza być w sposób arbitralny przyjęte. Na etapie geologicznego dokumentowania złóż może być zastosowany trojaki sposób ich określania:

1) oparty na analogii, przyjmujący odpowiednie ich wartości na podstawie dotychczasowych doświadczeń górnictwa,

2) oparty na przybliżonym rachunku ekonomicznym, biorącym pod uwagę istniejące dane statystyczne dotyczące kosztów pozyskiwania i cen surowców mineralnych,

3) oparty na danych dotyczących wymagań technicznych i technologicznnych eksploatacji i przeróbki kopalin, uwzględniający normy bezpieczeństwa pracy i wymagania stawiane surowcom mineralnym jako produktom handlowym.

Taki sposób definiowania złóż i ich zasobów geologicznych zilustrowano przykładem złóż rud miedzi.