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АНАЛИЗ ПОХОДОВ К ОЦЕНКЕ ЗАПАСОВ ПОЛЕЗНЫХ ИСКОПАЕМЫХ

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Аннотация.
Вопросы оценки месторождений полезных ископаемых сегодня очень актуальны. Это определило цель данной статьи, заключающуюся в том, чтобы заполнить пробел между теорией и практикой, который до сих пор не преодолен. Статья нацелена на всестороннее описание этих проблем, с тем, чтобы показать наиболее ценные составляющие различных моделей оценки запасов полезных ископаемых. После изменений экономической ситуации во многих европейских странах критерии оценки месторождений полезных ископаемых существенно изменились, и авторы многих «пересчетов и вычислений» используют различные, зачастую непригодные, методы, главным образом из-за отсутствия возможности ознакомиться с современными и комплексными методами оценки на практике. Поэтому в данной статье описаны результаты анализа подходов к оценке месторождений полезных ископаемых, что может быть полезно для экспертов-практиков.

STATE OF APPROACHES TO EVALUATION OF MINERAL DEPOSITS

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Abstract.
The issue of mineral deposit' evaluation is very topical and the aim of this article is to fill a gap between theory and practice, which with far has been empty. The presented paper is aimed to describe these issues in a comprehensive way to show the most useful components of different models of mineral deposits evaluation. After the changes in the economic systems in many European countries the criteria of assessment and evaluation of mineral deposits have changed significantly, and authors of these "recomputations and calculations" use various, often unsuitable methods, mainly because they have never had an opportunity of becoming acquainted with modern and comprehensive methods of mineral deposit evaluation. So this article describes the results of the analysis of approaches to mineral deposits evaluation and might be a contribution for experts from practice.

Introduction

Value and *price* are two basic financial categories causing misunderstandings in studies dealing with deposit evaluation and investments in the mining industry.

Price is expressed in money by economists.

Value is expressed by the degree of the owner's desire.

The following paragraph summarizes some types of values, which can be used in the process of deposit evaluation:

– *market value*,

– *full "cash" value*,

– *transfer value*, which corresponds to the existing value of ownership or property defined by the price that is necessary for the transfer of the property. The concept of the transfer is in fact identical with the cost approach of the deposit evaluation,

– *capitalised value*, or the sum of discounted next year's profits (net incomes) generated by the property. The capitalised value is a synonym of the cost approach in the evaluation of deposits and property of a mining firm,

– *accounting value*, original investments recorded in the accounting books reduced by depreciations and amortization recorded in the accounting documentation,

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– *insurance value*, which corresponds to the insurance price to which the property has been insured against loss or destruction.

Each of the above notions has its own specific meaning and can be determined by the amount of money in a specific situation. Hence the answer to the question "*what is the deposit price?"* is its value [3].

Price of the industrial mineral deposit

Price of the industrial mineral deposit can be determined on the basis of the deposit evaluation. The evaluation of mineral deposits is a specific problem, which is solved by classical methods of the evaluation of production enterprises. Principally two possibilities exist: to evaluate a deposit as land or to consider it a production enterprise that creates profit by its activities. Then the deposit is evaluated as a mine, and is considered the means of money production. Hence its price is equal to the present value of future (assumed) net incomes from the extraction with regard to the time horizon, the cost of the invested capital, inflation and risk. The indicator of the industrial mineral deposit may then be expressed by the *net present value* (NPV), *cumulative cash flow* (CCF), Morkill's formula, Hoskold's formula and others [11].

Deposit as a land

1) The price of a deposit is defined as the average statistic price of lands bought for mining purposes in various time periods in the same state. This procedure may be applied if the required statistic data is available. When evaluating a deposit as land it is possible to multiply the deposit area by a certain unit tariff that reflects the raw material type.

2) The deposit price is derived from the volume (tonnage, cubature) of proved reserves and the value of 1 t or 1 m^3 of the raw material or from selling or purchase prices of analogical deposits in the past years in similar economic and geographical conditions. Average statistic prices of land bought for mining purposes in various years in a given state are updated using the following formula:

$$FV = PV * (1+i)^n \tag{1}$$

where: FV - is the future value of money,
PV - is the present value of money,
i - is the rate of return of state bonds,
n - is the difference between the year of purchase and the previous year the value of which is updated.

A linear regressive analysis of updated values provides the "right" price for a monitored year. This procedure can be applied only if statistic data is available.

1) The deposit price is defined by means of the price of land on the surface above the deposit:

$$P = x.S \tag{2}$$

where x - is a coefficient >1,
S - is the price of the surface above the deposit e.g. farm land, forest, etc.

Deposit as a production enterprise

1) The deposit price is set by means of parameters related to the price of extracted raw materials, quantity of reserves and the mine's annual production (relations 5 and 6):

$$P = p.n.C.N \tag{3}$$

where: P - is the sales price of a mine,
p – is the price of extracted raw material,

n – is the standard price coefficient (0.05),
C – is the mine's annual production (capacity),
N – is the average life span of the mine (11.26 year).

$$P = p_r.C.N \tag{4}$$

where: p_r – is the standard price of extracted raw material ($p_r \div 0{,}01$ p, where p - raw material price),
C - is the mine annual production (capacity),
N is the average life span of the mine (30 years).

2) The deposit price is defined by means of costs spent on the geological exploration, in accordance with the following relation:

$$P = Q(c.k + p.l) \tag{5}$$

where: P - is the price of occurrence or deposit,
Q - tonnage of reserves of the given category in accordance with the degree of geological assurance (e.g. *proved, probable*, etc.),
c - specific exploration costs for a given category,
k - standardized coefficient,
p - price of raw material,
l - standardized coefficient.

3) The deposit price is defined by standardized coefficients that take into consideration the category of deposit exploration, depth of its location, basic mining indicators and the sale product price on the global markets:

$$P = Q.K_2.[((a + b)/(Q + c.d^{-\frac{1}{2}})).K_1 + n.p.v.e/10^4] \tag{6}$$

where P - is the deposit price,
K_2 – is the standardized coefficient according to the exploration categories, i.e. geological assurance (e.g. 0.7 for C_2, 1.0 for C_1, 1.2 for B),
a, b, c – are regressive coefficients,
d – is the depth of location of the mineral accumulation
K_1 – is the standardized coefficient,
n – is the standardized coefficient (=0.01)
p – is the price of the metal e.g. in the London stock exchange of metals (LME),
v – is the recovery,
e – is the yield.

2) The deposit price (accumulation of the industrial mineral) is based on exploration costs and theoretical assumptions about the possibilities of its use:

$$P = TC.k \tag{7}$$

where: P - is the price of accumulation,
TC - total exploration costs,
k – is the standardized coefficient (k = 0.5 up to 2.0 in accordance with the prospective of the occurrence or deposit use).

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3) The deposit price is set by references to recent purchases of the analogical occurrence/deposit/mines (if such an analogy exists).

4) The deposit price is a defined by means of the mineral price:

$$P = Q.p.n.m \tag{8}$$

where P - is the deposit price,
p – is the mineral price,
n – is the standardized coefficient in accordance with the degree of geological assurance,
m – is the standardized coefficient (0.1 – 0.01)[10].

Market price of a deposit

The market price is a value determined in a public market through harmonization of seller and buyer requirements. The market price is defined by offer and demand as well as by sales conditions. However, the application of the market approach to mining results in serious practical problems. Let us mention at least the two most significant:

– mining properties are sold only to a limited extent, which results in a reduced availability of comparable data,

– each deposit is unique due to its qualitative properties, size, geographical position, range of mining operations and many other parameters. Hence any data on the value of a mining property is usable only very rarely. In order to enable the application of market data a similar property value in the same time must be considered, because market conditions change in time (extraction costs, sales price of a final product, level of information about a deposit, etc.) [1].

Three approaches are available for the market price estimation: *cost*, *market* and *revenue* approaches.

Cost approach

Using this approach a purchaser is not willing to pay more than costs covering gained land, buildings and machinery equipment. However the correlation between costs for buildings and machinery equipment and the value of the property is very problematic. If the same funds are invested into buildings and machinery equipment in an extremely high grade deposit on one hand, and in a deposit with cut off grade conditions on the other, the market value of these two mines is different. Similarly, the value of a treatment plant in the exhausted deposit is very low, regardless of its possible high technological level. Hence the cost approach can only seldom be accepted for the estimation of deposits and mining ventures.

Market approach – method of market capitalization

The market price of a deposit is formed by the product of the stock exchange price of shares of a corresponding mining venture and the total number of shares that form the fixed assets of a company. Thus it is theoretically possible to buy a mining venture by purchasing shares of a corresponding mining company in a stock exchange or a security market. However, the purchase of a large package of shares can immediately change their value. Therefore such a package is not purchased on the stock exchange, but directly from shareholders. Problems can also result from the fact that shares represent the entire venture, but the property of a mining company can involve more than one deposit (single mine).

Within the framework of the market approach the respecting of the market value, which is conditioned by supply and demand, is considered the best method of setting the deposit price. The market approach assumes that a purchaser will not pay for the ownership more than he would pay for the acquisition of a required part of the ownership. The concept of market approach assumes conditions of the open market during a sufficiently long period of time, skilled buyers and sellers, absence of pressure on buyers to buy or on sellers to sell, as well as a sufficient number of transactions that contribute to the creation of a stable market [22].

However, when we are not considering the purchase of a company as such, but the estimation of the mining venture price for which it could be purchased, then this price will certainly not be a simple multiple of the price of one share of this venture by the estimation day and number of shares that form its fixed assets. From the above it is obvious that the method of the market capitalization has serious practical limitations. In spite of that the consideration of capitalization of a mining venture carrying out its business on the estimated deposit is an important factor in the estimation of its price.

Market approach – method of comparable sales

If there is a mine with practically identical technical and economic parameters, which has just been sold for a known price in the vicinity of the mine, which is estimated e.g. for sales purposes, then this price represents the proper price estimation also for this estimated mine. Of course, only under the prerequisite that the circumstances of both sales are also identical (free market, financial or time pressure or its absence).

However, the described case is extremely exceptional. More often it is possible to compare certain key parameters of the reference set of traded areas with parameters of the estimated area, some of which may be practically identical and others may vary in their time sequence. One of these parameters can be the production price of a unit of excavated and sold raw material commodity. A problem may arise also due to the fact that usually more types of commodities are mined simultaneously (e.g. natural gas is often excavated along with crude oil), and then they are calculated to gain comparable values [2], [7].

Revenue approach

In this approach the value of ownership or property of the investment character is estimated by the calculation of next year's net profit gained from the ownership of property and its discounting of the present value using the relevant interest rate. Before World War II the notion of *revenue* was understood as the net profit (*Hoskold* and *Morkill's formulas* were used for its quantification). After World War II, using the method of *net present value* (*NPV),* the *cash-flow* value, i.e. the sum of the net profit plus depreciations, has been considered the revenue.

The *Hoskold's formula* has the following form:

$$PV = \frac{A}{\frac{i}{(1+i)^n - 1} + r} \tag{9}$$

where PV - is the present value,
A - is the annual profit (annuity),
i - is the safety or reinvestment interest rate,
r – is the risky interest rate,
n – is the number of years.

Morkill's formula:

$$PV = A\frac{(1+r)^n - 1}{r(1+r)^n} \tag{10}$$

If the expression $(1+r)$ is replaced by the interest coefficient q, where $q = 1 + p/100$ and p is the interest rate in percents, then Morkill's formula takes the following form:

$$PV - A\frac{q^n - 1}{q^n(q-1)} \tag{11}$$

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The expression $\left(q^{n}-1\right) / q^{n}(q-1)$ is tabulated in interest tables as a multiplier for different interest rates and time periods of various duration.

The Net present value (NPV) is calculated as follows:

$$\mathrm{NPV}=\sum_{j=1}^{n} \mathrm{CF}_{j}(1+r)^{-n} \tag{12}$$

where NPV - is the net present value,
CF_j - is the cash-flow in year *j*,
r - is the discount rate (revenue rate of the paid investment capital),
n - is the number of years.

The substantial difference between the evaluation of a deposit using the NPV method and Hoskold and Morkill's formulas is that the NPV uses a variable course of financial flows for individual years of the company business and the resulting value is not the value of future profits but the present value of that part of the profit which remains after subtracting a planned revenue *r* on the paid investment capital instead of the average profit annuity [27].

Method of "in situ" value
It calculates the deposit price as follows:

$$P = Q.p.m.n \tag{13}$$

where: P - is the price of the occurrence (deposit),
Q - is the quantity of mineral reserves in situ (without considering recovery, yield, etc.),
p - is the commodity price,
m - is the coefficient expressing the fraction of price *p*, which is calculated (0.001 – 0.003 for common metals, 0.1 for gold),
n - is the coefficient evaluating the degree of exploration of reserves (here it is defined in accordance with the classification of London IMM, the most widespread in the mining practice throughout world, valid until 1992),

- proved - 1.0 seller's standpoint,
- 0.8 buyer's standpoint,
- probable - 0.8 seller's standpoint,
- 0.5 buyer's standpoint,
- possible - 0.2 seller's standpoint,
- 0.0 buyer's standpoint.

Other methods of defining the deposit *market value* include:

– *A balance method (of accounts value),* which consists of the calculation of own resources on a passive side of the balance sheet of a mining venture. Even though it is easy to calculate, it does not say anything about the economic potential of mines based on mineral reserves and future revenues from its extraction. It is the sum of the following items:

real estates – depreciations + inventory + accounts of debtors + cash – debts – accounts of creditors

However this defines the price of a mine, not a deposit. As a rule, the reserves of industrial minerals contained in a deposit are not included in the account balance of mining ventures. The case, when reserves themselves have been the subject of the purchase represents an exception [19].

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– *A method of capitalized payments for mining activities (the so called royalties)*. The deposit price is derived from the payment for mining activities (the so called royalties), which is paid annually during the entire extraction period in a deposit. This payment is defined by a percentage of the turnover of the mining venture gained for the sales of the extracted commodity. As a rule it constitutes 8 - 15 % of the mine's turnover gained from the sales of the extracted commodity. This method is considered, when the deposit or mining venture owner rents a deposit or mine for a flat payment paid in advance for a certain number of years. The payment is a multiple of the quantity of extracted raw material *T* and financial rate *s* for the extracted unit of the *T*.

$$R = s.T \tag{14}$$

The definition of the financial rate value *s* is problematic. A too high rate, which can achieve up to 50% of the price of extracted sold product can have a destructive impact on the profitability of a mining venture [14].

– In case of lacking actual or relevant data, the evaluation can be made by means of a detailed calculation model. However, experience proves that due to production limitations, delayed payments, reserves in storage houses and other serious facts affecting the deposit value, it is difficult to obtain the appropriate data.

Special cases of evaluation

In certain practical cases standard binding procedures of mining object evaluation are used. The following are presented for the sake of illustration:

Property returns of mining ventures in Michigan, USA, are annually based on the evaluation of mines by the so called *Hoover - Finlay* method. This method uses the Hoskold's formula, i.e. the estimation of future average annual profit during the expected lifespan, with both reinvestment and revenue interest rates set to 6 %.

In England and Wales the evaluation exploitation facilities for property returns is based on three chargeable items:

1) the calculation of the mining payment (royalty),
2) the calculation of payments for using buildings and facilities to the amount of 5 % of their estimated value,
3) the calculation of payment for occupating a territory

The total value of the mining property is calculated as the sum of 50 % of the 1st item + 100 % of the 2nd item + 50 % of the 3rd item [14].

In France owners of agricultural land rent it for long term periods for the extraction of rock and gravel sand under the condition that after recultivation it is returned back to them for a flat payment in the amount of double or triple the price of this land regarded as agricultural. The land owner usually invites entities interested in extraction of a deposit under the surface of his land and auctions the rent price with them.

In Germany Treuhandanstalt in Berlin privatised mines in former GDR using two simple methods. A buyer could choose whether to buy a mine for the full sum for the price according to relation (6) at a standard life time of thirty years, or for the price according to relation (5) at a standard life span of 11.26 year, or to buy a mine "on instalments" in the amount of an annual royalty of 8% in case of a deep mine, and 15% in case of a surface mine, which would be paid until the completion of the extraction [12].

At present in Slovakia there is no standardized methodology of the mineral resource evaluation, although mediation of purchase and sale of land and buildings on the basis of general has been enabled by Notice 289/1990 of the Code since August 1, 1990. The notion "general price" summarizes three expert calculation methodologies defined in the Methodological instructions of the MS SR No. 820/98-50 from April 6, 1998, which can be used individually or in combinations:

– comparison of purchase prices,
– capitalization of net revenue,
– costs for building structures.

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From the viewpoint of evaluating mineral deposits, the methodology of net revenue capitalization is regarded as the most suitable. This methodology is usable when real estate is considered (e.g. also deposits considered for the extraction), which bring revenues and they are created with this purpose. Compared with the past, when the evaluation was based on actual revenues from the past three years, currently the evaluation is based on expected future revenues justified by *cash-flow.* The evaluation also accounts for price, sales and other risks of the future development.

If a large variety of mineral resource evaluation possibilities including mineral deposits are considered, the incorporation of all methodologies or only some of them into legal standards does not seem reasonable. At present (abroad) recommendations, such as, for example, "In the evaluation process procedures identifying the value, which correspond to the current situation, should be used" or "Unless otherwise ordered by a court or administrative office, an expert himself selects procedures identifying the value. However, the current situation and customs of fair trade relations contained in Austrian law on real estate evaluation should be kept" are considered more topical [10].

Prices of Mineral Raw Materials and their Development in the World Market

The basic mechanism that affects prices of mineral raw materials in the market is supply and demand. Supply and demand also enable speculations with prices. A major producer with sufficient supplies and reserves in production is able to reduce prices of raw material by increasing his supply and thus liquidate competition. Using an opposite procedure of the artificial reduction of offer it is possible to increase demand in the market and cause an increase in product prices. Producers, in order to keep or increase prices, can buy free reserves on the market [18], [6].

Inflation results in the fact that the value of money will be lower in the future than it is at present. When considering the price of raw materials, value of money is often taken as constant, because analysts are not able to estimate the long term developments of inflation. The price is set on the basis of the agreement between a seller and a buyer. The wishes of buyers and sellers regarding purchase and selling prices can be illustrated by Fig. 1. The demand curve has a decreasing and the offer curve has an increasing character. This course is in full compliance with basic economic theory.

Factors affecting supply:

- work force price,
- energy price,
- material price,
- quantity of required work,
- quantity of required energy,
- quantity of required material,
- price of capital,
- quantity of required capital,
- bought out parts and production technologies, other factors.

Factors affecting demand:

- price of goods,
- prices of all substituting goods,
- technology,
- wishes of customers,
- solvency of customers,
- other factors.

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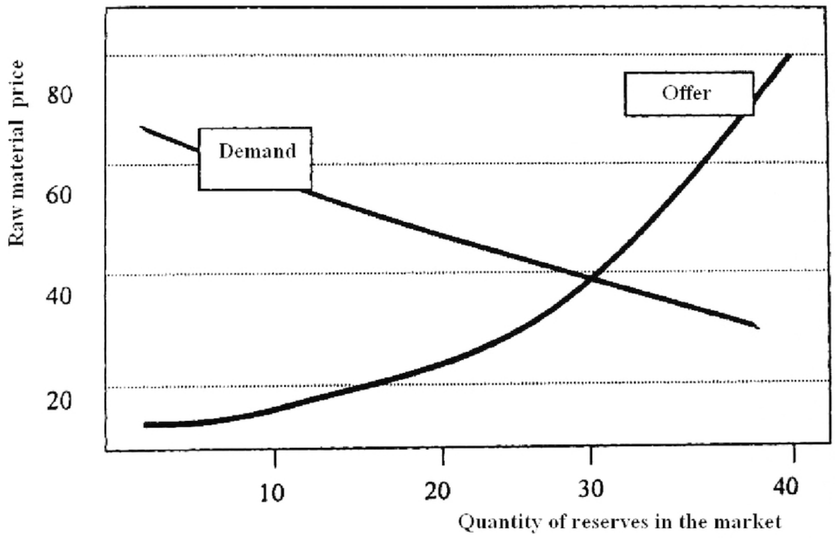

Fig. 1. Effects of demand and supply on the price of raw materials. The intersection of these two curves represents the price, for which a seller wishes to sell and a buyer wishes to buy raw materials

The estimation of the mineral raw material price in the future is a task, which can involve enormous errors. When evaluating a mining project within the framework of long term analyses it is difficult to predict the development of prices even over ten years. Prices of mineral raw materials and resulting products are determined first of all by the state of supply and demand, as with any other marketable items. However, both sides of the offer and demand equation contain serious complications that obstruct serious estimations of the price development.

On the side of demand it is possible to estimate quite accurately the demand for fuels and majority of other minerals, where the price development has more or less a cyclic character, because they are connected with capital goods and industrial production. Moreover, the need for minerals is behind the majority of economic activities, as the production accumulates reserves that can cover the initial increase of demand. In addition, the demand can be affected more by speculations than by the actual demand, and it is very hard to estimate this speculative demand.

As for the supply aspect, production fluctuations lasting even for several months may not be noticeable in world markets, due to the enormous quantities of products in „pipelines" transporting products to the location of consumption. On the other hand, mining ventures usually have a high level of fixed costs and often run their business in remote regions. These facts reduce the speed of their reactions to market fluctuations resulting from sudden economic changes, and prevent them from rapid shutdowns or re-openings. The offer is also affected by new discoveries, new technologies and recycling. In world markets large amounts of mineral raw materials and products manufactured on their basis are traded, therefore when estimating the development of their prices it is suitable to consider development trends and limitations of the world trade on the side of supply as well as on the side of demand.

With regard to mineral raw material trading it is suitable to divide them into two categories. The first category contains replaceable commodities with either minor or no differences in their quality between their producers. This category contains the majority of metals, the price of which is defined on the basis of agreed sales between buyers and sellers in one of commodity exchanges. The most significant are the *London Metal Exchange* (LME) and *the New York Commodity Exchange* (Comex) [8].

The other category includes the majority of other minerals. In this case a product from each mine has its own analyses that may significantly affect the price presented in the market. This category involves the majority of industrial raw materials, e.g. coal, the price of which is defined mainly by the its caloric value and sulphur content. The sale price of these raw materials results mainly from individual negotiations between sellers and buyers. Obviously, prices are also affected by the price of similar commodities in the world and local markets.

Commodity stock exchanges like LME or Comex are a formal auction sale in the free market, where buyer and seller trade mutually accepting the sale price. In order to enable these transactions

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tradable commodities have to meet standard quality, quantity and form conditions. A condition of proper functioning of a commodity exchange is a sufficient number of sellers, buyers and commodities that meet the relevant requirements. For example, copper, which is tradable mainly in cathode form, must meet extensive quality tests, and must be listed on the stock exchange, while it is possible to select, whether it will be traded on the LME or Comex.

Even though the volume of minerals and products made directly from minerals currently traded in commodity exchanges is relatively small, published transaction prices are crucial in defining prices for majority of similar materials all over the world. For example, copper producers may set prices that are a little increased or little decreased compared to Comex prices, depending on the quality and form of copper offered on the market. Customers may pay producers slightly higher prices as quoted in the stock exchange, for the sake of maintaining good relations with producers. In copper trading further increases of price compared with cathode copper may occur in cases of copper wire offer.

Along with the subtle setting of prices for different quality and form of commodities, as stated in the previous text, producers have only limited possibilities to change prices. As these minerals are replaceable, a customer does not wish to pay more for e.g. copper from Arizona than that from Zambia. Raw materials traded in a stock exchange are usually high value metals, where transport costs do not represent a significant part of the mineral sale price. Thus, with the exception of minerals, which are limited by certain import quotas that break the system, metals are genuine world commodities and dramatic deviations from stock exchange set prices are exceptional.

However, the majority of mineral commodities are sold for prices defined in individual contracts between sellers and buyers on the basis of long term relations. This is the selling method in the case of most industrial minerals and coal. Although there are certain orientation prices for a large scale of commodities published in various journals, such as e.g. *Mining Journal* or *Coal Week,* they however provide just rough instructions for the creation of current prices of commodities. Smaller quantities of these commodities, e.g. coal are sold for *spot market prices.*

Due to mutual advantages a great deal of coal contracts have been signed for long time periods of 5, 10 and even 15 years. Many of these contracts contain provisions protecting sellers from inflation or possible increases in various types of taxes and fees. Contracts protect seller's profits by means of sale price indexing, e.g. by the so called *consumer price index* (CPI), or *producer price index* (PPI). Some producers negotiate long term contracts on the basis of the so called *plus costs.* A typical approach in this case is to pay the seller 110% of the production costs.

There are many coal producers, who do not enter the market of long term contracts. They prefer immediate sales in local markets (*spot market*) and maximize revenues as along as the market allows for that. These producers profit mainly from energy crises and political instability.

Prices and quantities of raw materials in the world market, as already mentioned, are controlled by the supply and demand from the side of producers as well as sellers, also in case of the so called leading world producers. The example of a situation when a leading producer controls his own selling quantities of raw materials is e.g. OPEC-Organization of Petroleum Exporting Countries, which itself controls extracted and sold quantities within the framework of membership countries, to prevent uncontrolled development of crude oil prices that might result in the entry of new countries and producers to the crude oil market and reduction in possibilities of crude oil sales. (As examples the results of crude oil crises in 1973 - 1975 and 1979 – 1981 can be cited.)

Prices of mineral raw materials in world markets can be documented in graphs and tables by means of the so called long or historic time sequences.

Fig. 2 shows the development of average monthly prices of platinum in 1989 – 1991, being a typical commodity traded in a commodity exchange. Along with the shift of average platinum prices from month to month, the picture illustrates also the trend of the platinum price drop in London metal stock exchange since the second half of 1990 until the end of the analysed period. Fig. 7 displays the development of sulphur prices throughout the same time period [5].

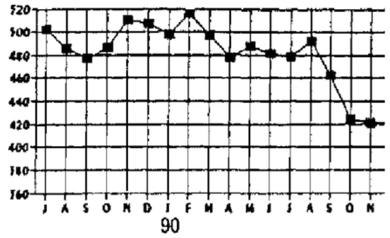

Fig. 2. Development of platinum prices in the world market. Platinum (USD/oz). London metal stock exchange

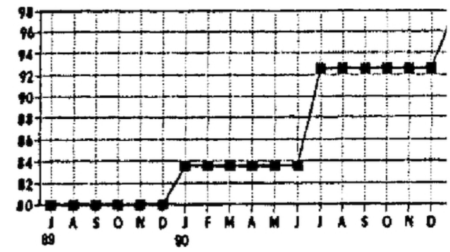

Fig. 3. Development sulphur prices the world market. Sulphur (USD/t). Export Canada

Figures 2 and 3 prove that producer prices of sulphur are more balanced than average monthly prices of platinum in the commodity exchange. Producer prices follow a long term trend; however, they are constant for a certain period of time. By coincidence, the tendency of the sulphur price development is opposite to that in the case of platinum, as the sulphur price increased during the monitored period.

The price development is affected also by political and economic events of global importance. This fact can be proved by the development of prices of some non-ferrous metals (tin, copper, lead and zinc) during the time period of 1915 - 1975. Prices of copper, lead and zinc oscillated around the decreasing trend until the outbreak of World War II. The price of tin oscillated around a constant mean value until the outbreak of World War II. It was interesting to witness some rapid price variations. For example, a sudden drop was recorded in 1921 and 1931. On the opposite, a significant price increase occurred in the period of 1925 - 1927. These years were connected with world economic crises and subsequent recession. After World War II prices of all four monitored elements kept increasing until 1951 (in case of copper until 1955). The price growth was connected with a period of the increased demand in raw materials, when Europe was rebuilding its economies destroyed during the war. After 1951 or 1954 a significant drop of prices occurred, either temporary or even more permanent. Prices of copper and tin started gradually increase after short temporary drop. The lead price kept dropping until the beginning of seventies, and then it started to increase again. The zinc price had a decreasing tendency during the entire period after 1951. Another common significant price increase occurred in the period of 1964 - 1966, in 1968 and in 1974.

The price prognosis for a few future years consists in predicting many individual items affecting offer and demand. This brief explanation is sufficient to understand, why it is so difficult to forecast the development of prices [24].

As already mentioned, costs spent by a mining company on the extraction and processing of raw material are not the criteria for setting the product price. A mining company either undertakes at a profit and places its goods in the market or cannot undertake at a profit and closes mines. Government interventions to some products in a form of subsidies into mines are provided only in case if the government considers the raw material strategic or in order to keep employment rate for citizens in a region that lacks other job opportunities. Approaches taken by different countries to solve this issue vary.

Sale of concentrates

The sales of concentrates are important for those mining ventures, which extract ore and their sales products are concentrates. The typical example is concentrates of polymetalic ores. Concentrates are sold to brokers or directly to metallurgic works. A large volume of this market is constituted by the copper industry, where e.g. the Japanese dispose of a large number of finalizing ventures.

A transaction between a concentrate producer and a customer representing a metallurgical company is controlled by a customer. Basic requirements in a contract are:

- regulations specifying the weight, sampling and humidity,
- limitations that specify limits or degree of possible derogations between seller and buyer's requirements and define how possible disputes are resolved,
- conditions of loading, transport, insurance and liability for incurred damages, which are represented by standard regulations summarized in INCOTERMS,

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– compensation of damages with specification of procedure, pursuant to which business partners agree to solve disputes and claims. It is often specified, according to which jurisdiction and by which court possible disputed will be solved,
– environmental issues. A seller can be asked to declare presence of harmful matters in sold goods and environmental pollution risks due to future use of sold concentrates.

A mining company calculates its incomes from the concentrate sales by means of *net smelter return* - ***NSR***.

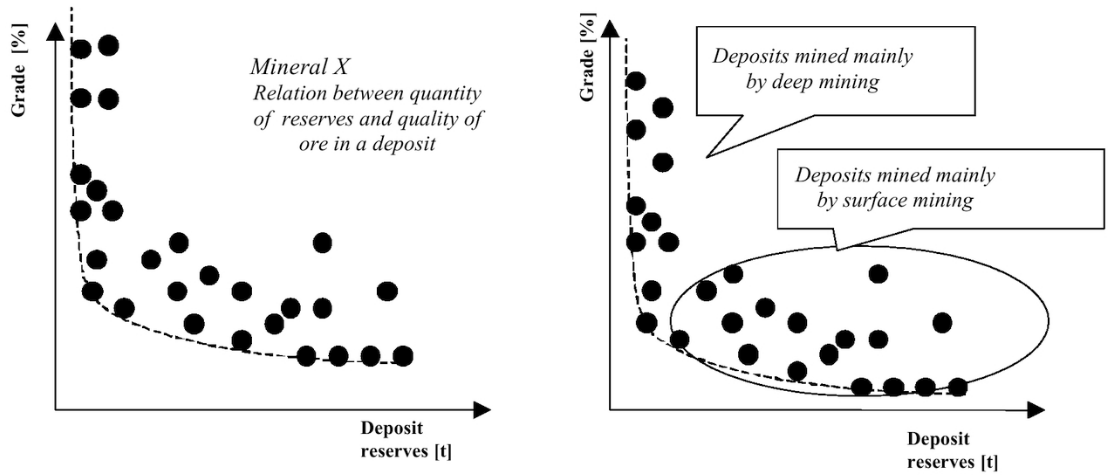

Fig. 4. Position of mineral X in the world (a filled circle represents one or a group of deposits with identical reserves and grade of its ore)

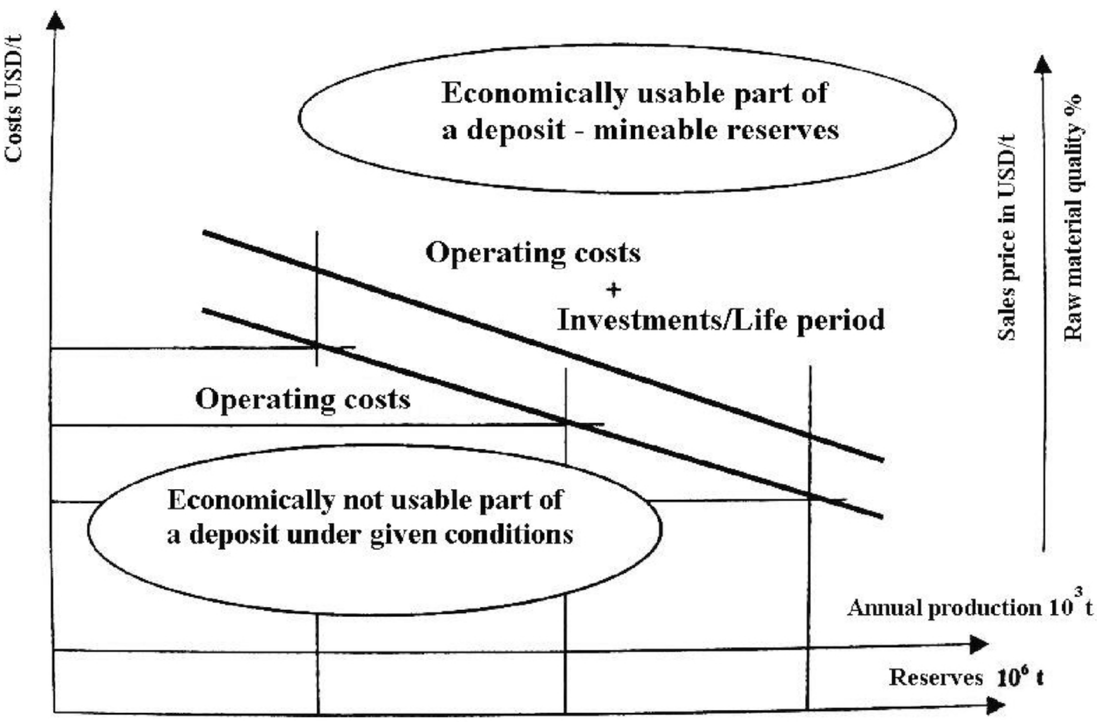

Fig. 5. Setting the goal: what will be extracted in the deposit

For some ore raw materials price quotations are available for concentrates and raw ores, e.g. for iron ore, wolfram, antimony and uranium concentrates. Prices of these raw materials are usually quoted with regard to the percentage of metals in concentrates. Then the NSR value is a multiple of the metal element content in raw ore (e.g. high percentage Brazilian iron ore) or in traded concentrates and unit prices of ore or concentrate. For the final NSR value a producer must subtract transport costs, which are his costs according to the contract [25].

Deposit Evaluation

Each industrial mineral deposit is unique due to its position, reserves, grade and other mining and geological conditions. Having been exhausted it cannot be replaced even though it is often possible to find, rent or buy a similar deposit. This fact makes comparison of the deposit price and price of another deposit difficult, and also obstructs the evaluation of individual mining operations in deposits. In the course of exploration the risks are reduced, until it is replaced by certainty that the prospecting will lead to a new deposit of industrial minerals, which can replace the extracted deposit [15].

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