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Evaluation Methodology for Pre-Mining Potentiaity for Mineral Deposits

Davaasambuu Nachin

School of Mining and Geology, Mongolian University Science and Technology, Ulaanbaatar, Mongolia

Email address:
nda.nachin@gmgal.com

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Abstract: Here we introduce "Pre-mining potentiality of mineral deposit" and gets marked "P_{pm}" under this methodology, which comprehensively represents the mining and geological conditions in the crust, the geologic parameters, study and calculation of mineral reserves, mining method, moreover assessments of other studies such as for operation, location and marketing capabilities, a warning forecast of the economic viability and environmental impact on nature. The pre-mining potentiality evaluation of mineral deposits can be considered as the most comprehensive pre-production assessment of a deposit, which makes it possible to compare it with other same type deposits and to assess and determine the priorities of this field. External factors, the method of mining development, production productivity, the technique and technology of the extraction system, the amount of capital investment, the professionalism and the capacity of management and financial capacity of the project executor, show the main effects on the actual magnitude of the final social and economic benefits that result from the overall implementation of the project. And the internal factors in it, deposits, mining and production and economic as well as environmental conditions, are the main foundation for those external factors. These internal factors need to be examined before operational phase or during mine development, with detailed study in the framework of consistent scientific research and consider clearly the logical and expected results of future mining operations. The following research works are carried out to develop a mineral deposit. Including: reconnaissance studies, geophysics, hydrogeology, geotechnical studies, resource delineation, evaluation work - a scoping study, preliminary and detailed feasibility studies, detailed environmental impact assessment. In international practice these research and evaluation works are called in general in Russian "предэксплуатационные исследования месторождения полезного ископаемого" and in English "pre-production evaluation for mineral deposit". These works of research and analysis for the development of a deposit are not feasible simultaneously for all similar deposits, which require a lot of time and cost, therefore, the possibilities of evaluation and comparison are not obtained, and their priorities are not well determined. So, here a scientifically methodological question is being considered to evaluate the pre-mining potentiality, which is based on the influences of the internal factors of a given deposit, regardless of time and cost, for evaluation, comparing and ranking in general.

Keywords: Pre-mining Potentiality, Classification of the Homogeneous Deposits, Mineable Potentiality, Industrial Potentiality, Economic Potentiality, Identical Deposits, Significance of Deposit, Productivity Orientation

1. Previous Word

Mineral deposits are evaluated in many ways through various dedication and methodologies. Namely, resource estimation, quality (standard) appraisal, geological evaluation, economic evaluation, geologic-economic evaluation, scoping study, prefeasibility to detailed feasibility study et-cetera.

All these methodologies have their own unique way of assessing, evaluating and appraising each mineral deposit, but all contain a goal of preparing the deposit for possible exploitation.

Most of these studies isolate the deposit in discrete situations and compare only few key parameters and specifications to similar types of best exemplary deposits (these may include active mines or fully fulfilled mines). Thus, this method neglects many other possibilities. In other words, the methodology is to put aside the other similar deposits and introduced only the pending deposit.

Currently, any mineral deposit is overly compared in terms of its containing useful mineral substance or in ore reserves as a large or small deposit [3]. This comparison is not enough for many of the same types of deposits. Therefore, it is necessary to develop a preliminary appraisal methodology for the field in terms of self-contained potentiality.

Here we introduce "Pre-mining potentiality of mineral deposit" and gets marked "Ppm" under this methodology, which comprehensively represents the mining and geological conditions in the crust, the geologic parameters, study and calculation of mineral reserves, mining method, moreover assessments of other studies such as for operation, location and marketing capabilities, a warning forecast of the economic viability and environmental impact on nature.

The pre-mining potentiality evaluation of mineral deposits can be considered as the most comprehensive pre-production assessment of a deposit, which makes it possible to compare it with other same type deposits and to assess and determine the priorities of this field.

External factors, the method of mining development, production productivity, the technique and technology of the extraction system, the amount of capital investment, the professionalism and the capacity of management and financial capacity of the project executor, show the main effects on the actual magnitude of the final social and economic benefits that result from the overall implementation of the project. And the internal factors in it, deposits, mining and production and economic as well as environmental conditions, are the main foundation for those external factors.

These internal factors need to be examined before operational phase or during mine development, with detailed study in the framework of consistent scientific research and consider clearly the logical and expected results of future mining operations.

The following research works are carried out to develop a mineral deposit. Including: reconnaissance studies, geophysics, hydrogeology, geotechnical studies, resource delineation, evaluation work - a scoping study, preliminary and detailed feasibility studies, detailed environmental impact assessment. In international practice these research and evaluation works are called in general in Russian “предэксплуатационные исследования месторождения полезного ископаемого” and in English “pre-production evaluation for mineral deposit”.

These works of research and analysis for the development of a deposit are not feasible simultaneously for all similar deposits, which require a lot of time and cost, therefore, the possibilities of evaluation and comparison are not obtained, and their priorities are not well determined.

So, here a scientifically methodological question is being considered to evaluate the pre-mining potentiality, which is based on the influences of the internal factors of a given deposit, regardless of time and cost, for evaluation, comparing and ranking in general [1].

2. Internal Factors and Evaluation Specifications of Mineral Deposit

Expressive and key characteristics of inherent factors are selected by evaluation specifications for the pre-mining potentiality evaluation and development of a given mineral deposit. Evaluation specifications are divided into mining, industrial, economic and environmental conditions.

Mineable conditions:

1) ore reserves of the deposit (the ore reserves of the deposit are the most important indicators for production and the economy, henceforth, are selected as the "basic potentiality or basic indicator" in this methodology);
2) content of main minerals or elements in ores;
3) Accessory mineralization aside from primary mineralization and elements in ores (here, apart from the main economic components, what minerals and elements are contained in ores that can be of value)
4) content of main elements and minerals in the accessory mineralization;
5) type of ore body (veins, lenticular, stockwork, etc.);
6) the depth of the ore body;
7) number of ore bodies (how many ore bodies this deposit consists of);
8) complexity of ore bodies (if the deposit consists of several ore bodies, then that will influence the development of the mine);
9) average thickness of the ore body;
10) the average width of the ore body;
11) average length of the ore body;
12) the inclination of the ore body (the inclination angle is considered for what effect it has on the development of the mine);
13) the strength of the ore body (according to the classification of Prof. Protodyakonov) [19];
14) the strength of overburden or enclosing rocks (according to the classification of Prof. Protodyakonov) [19].

Industrial conditions:

1) Method of extraction (open pit and underground mining or a combination of these methods) [5, 10, 11, 15, 18, 20];
2) readiness for operation (necessary research is required for mine development: sterilization, geophysical, hydrogeological, geotechnical studies and detailed environmental impact assessment and feasibility studies) [13, 16];
3) industrial conditions (regional and local infrastructure conditions for the development of mine) [4, 6, 12].

Economic and ecology conditions:

1) the ability of the market (production demand, the ability to deliver market demand and capacity, as well as price levels) [4, 8];
2) economic benefits (considering the results of empirical estimations of total investment, income and expenditure, state and local tax payments, net profit and the number

of employees, and life of mine, [14, 17].

3) impact on the environment (The level of negative impact on the environment) [2, 7].

3. The Classification of Same Type Deposits with Evaluation Specifications

All similar or same type deposits, that have been studied should be classified by these evaluation specifications. For example, in evaluating a copper deposit, all other known copper deposits within the country with estimated reserves and already with substantial amount of survey should be classified by this methodology [1].

This will enable an opportunity to rank these similar deposits by each specification. And for this classification to be successful these specifications need to be collected from their respective geological report for each deposit.

The classification is carried out according to the form shown in Figure 1. The specifications are divided into either three or five categories based on their individual quality, to determine the corresponding intervals of quantitative values. These categorization is dependent on the conditions of the national or global practices of the time of classification and is also dependent on the author's approach and expertise at that time. Figure 1 serves as a sample, so all the specifications are shown in one figure [1].

Specifications	Code of Classification	Groups of Classification				
		Best numerical value	Good numerical value	Average numerical value	Poor numerical value	Worst numerical value
Impact rate		I	II	III	IY	Y
		Basic potentiality				
Ore reserves of the deposit	A	Highest value	Above average value	Average values of interval	Below average value	Lowest value
		Mineable conditions				
Content of main minerals or elements in ores	B	Highest value	Above average value	Average value	Below average value	Lowest value
The number of accessory mineralization and elements in ores	C	Has two or more accessory mineralization	-	Has 1-2 accessory mineralization	-	No accessory mineralization
Content of elements and minerals in accessory mineralization	D	More than the estimated value	-	With estimated value	-	With uncalculated value
Type of ore body	E	Favorable for development	-	Convenient for development	-	Difficult for development
The depth of the ore body	F	Nearest depth interval	Semi-nearest depth interval	Average depth interval	Semi deepest interval	Deepest depth interval
Number of ore bodies	G	Consists of one ore body	-	Besides the main ore body has 1-2 more supporting bodies	-	Consists of more than 3 ore bodies
Complexity of ore bodies	H	Convenient for development	-	Difficult for development	-	Impossible for development
Average thickness of the ore body	I	Has thick interval value	-	Has average thickness	-	Has thin interval value
The average width of the ore body	J	Has wide width interval	-	Has average width interval	-	Has small width interval
The average length of the ore body	K	Has long length interval	-	Has average length interval	-	Has short length
The angle of attack of the ore body	L	Favorable for development	-	Convenient for development	-	Difficult for development
The strength of the ore body	M	very strong IY - IYa	-	stronger III – IIIa	-	Strong I - II
The strength of overburden or enclosing rocks	N	very strong IY - IYa	-	stronger III – IIIa	-	Strong I – II
		Industrial conditions				
Method of extraction	O	Surface mine	-	Combined mine	-	Underground mine
Readiness for operation	P	Well-made	-	Normally made	-	Insufficiently made on operation
Industrial conditions	Q	Best favorable conditions	Good conditions	Average conditions	Bad conditions	Worst difficult conditions
		Economic conditions				
The ability of the market	R	Favorable		Average		Difficult
Economic benefits	S	Extremely high probability	High probability	Average profitability	Low profitability interval	Unprofitable
Impact on the environment	T	Low impact rate	-	Average impact rate	-	High impact rate

Figure 1. *Sample of classifications on the evaluated specification of pre-mining potentiality for mineral deposits.*

Impacts of evaluation specifications are divided into 5 ranks between "best" to "worst" and are numbered in Roman numerals from I to V. Evaluation specifications are marked in Latin alphabet and is used as a classification code [1]. This allows the opportunity to mark each classification group through code. For example: Performance classification group "Content of main minerals of elements in ores" are encoded from the start with "highest" in the following manner BI; B-II; B-III; B-IV; B-V. Specifications of the "The ability of the market" are encoded from the beginning with "favorable conditions" for the next RI; R-III; RV, and so on [1].

These selected 19 (excluding the value for ore reserves of the deposit) specifications show how these may relate to the evaluation of pre-mining potentiality in deposits (Figure 2).

Here, the proportion of chosen specifications influence to pre-mining potentiality evaluation of mineral deposits supplied by this figure as follows: If data indices are classified into 3 groups, then the middle group (average numerical value) is considered non-influential i.e. normal, and the upper and lower groups would denote +5%, -5% respectively; if the group has 5 classification, while the middle group is considered to be the same non-influence that is normal, the best numerical value group is considered +5%, the good and bad numerical value is considered +3%, -3% respectively, and the worst numerical value is considered -5%. For mathematical processing, these percentages are represented by numerical indices as follows [1]:

1) the non-influential i.e. normal group is 1.0;
2) the group with influences +3, + 5% are represented by indices 1.03 and 1.05;
3) the group with influences -3, -5% are represented by indices 0.97 and 0.95.

The middle group of the classification show the normal 100% value of pre-mining potentiality for mineral deposits, so the other specification groups affect either positively or negatively due to their values. A logical principle is withheld that all 19 specifications for pre-mining potentiality not exceed ±95% (19 x 5%) [1].

Evaluation indices		1.05	1.03	1.0	0.97	0.95
Share of influence on evaluation, %		+5%	+3%	0%	-3%	-5%
Influence rate of specifications		I	II	III	IY	Y
Code of classification for mineral deposits	B	B-I	B-II	B-III	B-IV	B-V
	C	C-I		C-II		C-III
	D	D-I		D-II		D-III
	E	E-I		E-II		E-III
	F	F-I	F-II	F-III	F-IV	F-V
	G	G-I		G-II		G-III
	H	H-I		H-II		H-III
	I	I-I		I-II		I-III
	J	J-I		J-II		J-III
	K	K-I		K-II		K-III
	L	L-I		L-II		L-III
	M	M-I		M-II		M-III
	N	N-I		N-II		N-III
	O	O-I	Q-II	O-III	Q-IV	O-V
	P	P-I		P-II		P-III
	Q	Q-I		Q-II		Q-III
	R	R-I		R-II		R-III
	S	S-I	S-II	S-III	S-IV	S-V
	T	T-I		T-II		T-III

Figure 2. *Share of influence, their indices and influence rate evaluation specifications for the pre-mining potentiality evaluation mineral deposits.*

This classification is the foundation for evaluation of the pre-mining potentiality of mineral deposits [1].

4. Determining the Basic Potentiality Evaluation for Mineral Deposits

Classification code for the basic potentiality is "A" and an evaluation index is chosen to evaluate the deposits with the same starting point for any deposit at 100% potentiality, which is expressed by evaluation index 1.0 [1].

Deposit reserve sizes vary depending on its mineral type. For example, gold reserves of placer and hard rock deposits are estimated at tens of kilograms to tens of tons and non-ferrous metals deposits are estimated at hundreds of thousands of tons to several hundred million tons, reserves of coal deposits from several hundred million tons to several billion tons. Thus, for the determination of basic potentiality evaluation, indices were correlated with the divided batches relative to their reserve amount.

The deposit basic potentiality marked "Pb" in the frame of this methodology and is determined by the following [1]:

$$Pb = e + (c + a : b \cdot d);$$

Wherein: e, c, a, b, d - number columns of Figure 3.

№	Deposit reserve interval (ton)	Evaluation batch of reserves (ton)	Deposit reserves interval index	Indices increase for each batch	Main indices of reserves	Indices increase on the reserves main indices
0	A	B	C	D	E	F
1	0.01 - 0.09	0.01	0.1	0.01	1.0	0.1- 0.19
2	0.1 - 0.9	0.1	0.2	0.01	1.0	0.2 - 0.29
3	1.0 - 9 .9	1.0	0.3	0.01	1.0	0.3 - 0.39
4	10.0 – 99.9	10.0	0.4	0.01	1.0	0.4- 0.49
5	100.0 – 999. 9	100.0	0.5	0.01	1.0	0.5 - 0.59
6	1 000.0 - 9 999. 9	1 000.0	0.6	0.01	1.0	0.6 - 0.69
7	10 000.0 - 99 999.9	10 000.0	0.7	0.01	1.0	0.7 - 0.79
8	100 000.0 – 999 999.9	100 000.0	0.8	0.01	1.0	0.8 - 0.89
9	1 000 000 – 9 999 999.9	1 000 000	0.9	0.01	1.0	0.9 - 0.99
10	1 0 000 000 - 99 999 999.9	10000000.0	1.0	0.1	1.0	1.1 -1.9
11	100 000 000 - 999 999 999.9	100 000 000.0	2.0	0.1	1.0	2.1-2.9
12	More than 1 000 000 000	1 000 000 000.0	3.0	0.1	1.0	3.1 - 3.9

Figure 3. *Reserves of different deposits and indices increase for each batch.*

For example:

1) Basic potentiality for deposit with reserves of 70 kg or 0.07 tons.

Pb=1.0+(0.1+0.07 : 0.01· 0.01)=1.17;

2) For deposits with reserves of 200 kg or 0.2 tons.

Pb=1.0+(0.2+0.2 : 0.1 ·0.01)=1.22;

3) For deposits with reserves of 3.726 tons.

Pb=1.0+(0,3 + 3.726 : 1.0 ·0.01)=1.33726;

4) For deposits with reserves of 11.543 tons.

Pb=1.0+(0.4+11.543 : 10.0·0.01)=1.411543;

5) For deposits with reserves of 542 tons.

Pb=1.0+(0.5+542 : 100.0 ·0.01)=1.5542;

6) For deposits with reserves of 7563 tons.

Pb=1.0+(0.6+7563 : 1000.0 ·0.01)=1.67563;

7) For deposits with reserves of 45600 tons.

Pb=1.0+(0.7+45600 : 10000.0 ·0.01)=1.7456;

8) For deposits with reserves of 976 453 tons.

Pb=1.0+(0.8+976453 : 100000.0 ·0.01)=1.8976453;

9) For deposits with reserves of 9 476 283 tons.

Pb=1.0+(0.9+9476283 : 1000000.0 ·0.01)=1.99476283;

10)For deposits with reserves of 49 674 832 tons.

Pb=1.0+(1.0+49674832 : 10000000.0 ·0.1)=2.49674832;

11)For deposits with reserves of 892 674 832 tons.

Pb=1.0+(2.0+892674832 : 100000000.0 ·0.1)=3.892674832;

12)For deposits with reserves of 6 298 476 283 tons.

P_b=1.0+(3.0+6298 476283 : 1000000000.0 ·0.1)=4.6298476283;

These examples show that the evaluation can detailed in decimal fractions and, it is for the author to decide the decimal approximation.

As shown in figure 3 and from the examples, the basic potentiality of mineral deposits can range between 1.1-4.9.

5. Other Potentiality of Deposits and the Determination of Them

The concept of a complex condition that occurs because of simultaneous impacts of mining and technical characteristics besides mineral reserves shall be called "mineable potentiality" and marked as "Pm". This potentiality is determined by the geometric mean (average) of the influence indices from B to N, as shown in Figure 1 [1].

$$P_m = \sqrt[n]{I_{B1} \cdot I_{C2} \cdot I_{D3} \cdot I_{E4} \cdot I_{F5} \cdot I_{G6} \cdot I_{H7} \cdot I_{I8} \cdot\ I_{J9} \cdot I_{K10} \cdot\ I_{L11} \cdot\ I_{M12} \cdot\ I_{N13}\ \cdot\ \dots\ \cdot\ I_n} \quad (1)$$

Wherein: Pm – mineable potentiality of the deposit; IB1 – index of main component in ores; IC2 –index for accessory mineralization; ID3– index for accessory mineralization content; IE4– index for type of ore body; IF5 –index for depth of ore body; IG6 –index for number of ore bodies; IH7 –index for interconnection of ore bodies; II8 –average thickness index of ore body; IJ9 –average width index of ore body; IK10 – average length index of ore body; IL11 –index for ore body inclination; IM12 – index for ore body strength; IN13 –index for overburden and enclosing rock mass strength; n –number of mineable potentiality specification;

Another concept is the availability of industrial capabilities of the deposit, which is called "industrial potentiality" and denoted as "Pi ". This potentiality is determined by the geometric mean (average) of the influence indices from O to Q as shown in Figure 1 [1].

$$P_i = \sqrt[n]{I_{O1} \cdot I_{P2} \cdot I_{Q3} \cdot \ldots \cdot I_n} \tag{2}$$

Wherein: Pi –industrial potentiality of the mineral deposit; IO1–index for method of extraction; IP2 – index for readiness of mineral deposit; IQ3 – index for industrial conditions of the deposit; n – number of industrial potentiality specification;

One other complex condition arises because of the effects of economic-environmental specifications and is called "economic potentiality" field. Economic potentiality is marked "Pe" and is determined by the geometric mean (average) of the influence indices from R to T, as shown in Figure 1 [1].

$$P_e = \sqrt[n]{I_{R1} \cdot I_{S2} \cdot I_{T3} \cdot \ldots \cdot I_n} \tag{3}$$

Wherein: Pe – economic potentiality of mineral deposit; IR1– index for market ability; IS2 – index for economic benefits; IT3 –index for impact on the environment; n – number of economic potentiality specification conditions;

In the formulas 1, 2, 3 the number of respective specification is marked with the letter "n", it expresses that the number of specification depends on the author's choice.

6. Evaluation of Pre-mining Potentiality for Mineral Deposits

The mathematical expression for estimating the pre-mining potentiality of mineral deposits is determined with the 4 potentialities (the basic (Pb), mineable (Pm), industrial (Pi) and economic (Pe) potentialities) which were defined in the third and fourth sections of this methodology:

Formula 4

$$P_{pm} = P_b \cdot P_m \cdot P_i \cdot P_e; \tag{4}$$

The minimum value of mathematical expression for estimating pre-mining potentiality (Ppm) is 0.9438, the maximum value is 5.6742.

The maximum evaluation value for pre-mining potentiality is determined as follows [1]:

$$P_{pm}^{max} = P_b^{max} \cdot P_m^{max} \cdot P_i^{max} \cdot P_e^{max;} \tag{5}$$

$$P_{pm}^{max} = P_b^{max} \cdot \sqrt[n1]{1.05^{n1}} \cdot \sqrt[n2]{1.05^{n2}} \cdot \sqrt[n3]{1.05^{n3}} = P_b^{max} \cdot 1.158 = 4.9 \cdot 1.158 = 5.6742$$

The minimum evaluation value for pre-mining potentiality is determined as follows [1]:

$$P_{pm}^{min} = P_b^{min} \cdot P_m^{min} \cdot P_i^{min} \cdot P_e^{min;} \tag{6}$$

$$P_{pm}^{min} = P_b^{min} \cdot \sqrt[n1]{0.95^{n1}} \cdot \sqrt[n2]{0.95^{n2}} \cdot \sqrt[n3]{0.95^{n3}} = P_b^{min} \cdot 0.858 = 1.1 \cdot 0.858 = 0.9438$$

Wherein: P_b^{max}– the maximum value for the evaluation of reserve potentiality or basic potentiality; P_b^{min} - the minimum value for the evaluation of basic potentiality;

Wherein: P_b^{max} – the maximum value for the evaluation of potentiality reserves or basic potentiality deposit; P_b^{min} - the minimum value for the evaluation of basic potentiality deposit;

The evaluations of pre-mining potentiality of deposits allow opportunities for comparing same type deposits and rank them. Furthermore, it will serve a basis for sustainable development in preliminary estimates of mining capacity, number of personnel requirement, total investments and macroscopic planning.

Deposit rank		I class	II class	III class	IV class	V class
Pre-mining potentiality evaluation value of deposit		on the interval	on the interval	on the interval	on the interval	on the interval
Deposit number		by number	by number	by number	by number	by number
Hereof:	Surface mine	by number	by number	by number	by number	by number
	Combined method	by number	by number	by number	by number	by number
	Underground mine	by number	by number	by number	by number	by number
Occupied percentage of all deposits		percent	percent	percent	percent	percent

Figure 4. *Ranking mineral deposits by pre-mining potentiality.*

7. Ranking Same Type Deposits by Pre-mining Potentiality

The ranking of mineral deposits are differentiated into classes by types, for example [1]:

1) Precious metals and rare earth elements measure from several dozens of kilograms to several tons;
2) Fluorite, phosphate and zeolite measure from several hundred to several hundreds of millions of tons;
3) Non-ferrous and base metal deposits measure from a

few tens of millions to several hundreds of millions of tons;

4) Coal, shale and limestone deposits are expressed on a measure of several hundred million to a few tens of trillions of tons.

The author shall decide the ranking based on reserve estimates and the type of deposits. A sample model for ranking deposits are shown in Figure 4 [1].

8. Determination of Mining Capacity for a Given Deposit

After ranking the same type deposits, a reference of the mean annual capacity for each deposit class should be determined as per the most updated international practices, as shown in Figure 5 [1].

Deposit rank	Ore, Thous.t	Rock mass, thous.t	Rock mass, thous.м3	Rock mass per day, thous.t	Rock mass per day, thous.m3
I class	By interval	By interval	By interval	By interval	By interval
II class	By interval	By interval	By interval	By interval	By interval
III class	By interval	By interval	By interval	By interval	By interval
IY class	By interval	By interval	By interval	By interval	By interval
Y class	By interval	By interval	By interval	By interval	By interval

Figure 5. *Sample determination of annual productivity of same type deposits based on their ranking.*

The annual capacity references should be estimated between the intervals of 100 -150; 50 -100; 30 -50; 15 -30; 10 -15; 5 -10 year terms of development depending on the size of reserves, deposit type and the author's own calculations.

The sample here only refers for surface mining and specific calculations are required for sub-surface mining [1].

9. Determining the Required Technical Specifications for Mining Equipment

Deposits		Open pit		Daily productivity, t/per day	Open pit personnel, number	Processing plant personnel, number	Service personnel, number	Sum or minimum number of jobs
Characteristics	Rate	Annual productivity	Rate					
Very large	I	Super-powerful	I.1	***	***	***	***	***
		Powerful	I.2	***	***	***	***	***
Large	II	Powerful	II.2	***	***	***	***	***
		Medium	II.3	***	***	***	***	***
Medium	III	Medium	III.3	***	***	***	***	***
		Little	III.4	***	***	***	***	***
Little	IV	Little	IV.4	***	***	***	***	***
		Small-powerful	IV.5	***	***	***	***	***
Small	V	Small-powerful	V.5	***	***	***	***	***

***- within certain intervals

Figure 6. *Sample reference technical specifications of equipment for each deposit class.*

The following empirical formula and directories are used to select the respective workload for each equipment [17].

The diameter of the drill bit is determined by the following formula [17].

$$d = \sqrt[2]{\frac{M_d}{100}};\ \text{инч} \quad (7)$$

Wherein: Md – extracted rock mass per day, t

Capacity of excavator buckets

$$S=0.145 \cdot M_d^{0.4} \cdot 0.765;\ \text{м}^3 \quad (8)$$

Wherein: S –excavator bucket capacity, m3; 0.145 – constant; Md – waste and ore excavation per day, t; 0.765 –

the coefficient for converting the US "yard" to SI "m3";

Carrying capacity truck is determined by the following [17]:

$$t=9.0 \cdot S^{1.1}; \text{тн} \quad (9)$$

Wherein: t – carrying capacity of the truck, t

Workload, t/per day	D6T	D7R	D8T	D9T	D10T
0 - 50	x				
50 – 150	x				
150 - 250	x				
250 - 350	x				
350 - 500		X			
500 - 750		x			
750 - 1000			X		
1000 - 3000			x		
More than 3000				x	x

Figure 7. *Selection table for bulldozer (For example caterpillar's bulldozer) [9].*

10. Determination of the Minimum Number of Mining Jobs Created in Each Deposit Class

The following empirical formula are used for determining the minimum number of mining jobs created for each deposit class [17]:

For mine:

$$N_p = 0.034\, M_d^{0.8}; \quad (10)$$

For the Processing plant:

$$N_{pp} = 5.70\, M_d^{0.3}; \quad (11)$$

The number of service personnel is determined as 25.4% of the sum of mine and plant personnel.

A sample for determining the minimum number of jobs created in mining for each deposit class is shown in Figure 8 [1].

Deposits		Open pit		Main parameters of the mining equipment			
Character-is tics	Rate	Annual produc-tivit y	Rate	The diameter of the drill bit, mm	Capacity of the excavator bucket, м3	Carrying capacity of the truck, t	Productivity of the bulldozer, м3/per day
Very large	I	Super-power ful	I.1	***	***	***	***
		Powerful	I.2	***	***	***	***
Large	II	Powerful	II.2	***	***	***	***
		Medium	II.3	***	***	***	***
Medium	III	Medium	III.3	***	***	***	***
		Little	III.4	***	***	***	***
Little	IV	Little	IV.4	***	***	***	***
		Small-powerful	IV.5	***	***	***	***
Small	V	Small-powerful	V.5	***	***	***	***

***- according to calculated data

Figure 8. *Samples of the minimum number of jobs created in mining each deposit class.*

11. Conclusions

Through the development of this methodology to assess the pre-mining potentiality of mineral deposits will open the following features and benefits in the mining industry:

A. A new methodology for classifying minerals deposits by their inherent mining, industrial and economic specifications or characteristics.

B. The possibility for a concise and efficient way of classifying and ranking same type deposits based on their inherent mining, industrial and economic potentials.

C. The pre-mining potentiality allows the possibility for a preliminary reference of technical specifications for equipment, minimum number of jobs created, investments and economic benefits for each class of same type deposits.

D. These not only allow a swift comparison and correlation of deposits, but also allow for mining policy and mineral resource planning on macro scale and sustainable development.

References

[1] Davaasambuu N. Research of evaluation of pre-mining potentiality for fluorite deposits (on the example of Mongolia). UB., Thesis. 2015.

[2] Botin J. A. Sustainable management of mining operations. SME. Colorado, USA. 2009.

[3] Brief information on mineral commodities of Mongolia (Nonmetals). Mineral Resources Authority of Mongolia. Geological Information Center. UB. 2012.

[4] Byamba-Yuu Zh., Tsedendorzh S. Technical and economical analysis of the mining enterprise. UB. 2009.

[5] Billiam Hustrulid., Mark Cuchta. Open pit Mine Planing and Design. London. 2006.

[6] Granin I. V. Study of the mining regime for low-power steeply dipping deposits of considerable length. M., MGRI. 1966.

[7] Guzeev A. G. Design and construction of mining enterprises. M. Nedra. 1987.

[8] Davaasambuu D., Davaatseren G., Purvee J. Financial and economic evaluation of the mineral resources. UB. 2003.

[9] Caterpillar Performance Handbook-39. U.S.A. 1979-20096

[10] Laihansuren B., Parvev L., Ochirbat P., Haidav A., Mining engineer's handbook-6. Underground mining technology. UB. 2011.

[11] Melnikov N. V. Handbook on mining operations. M., Nedra, 1974.

[12] Ochirbat P., Tsedendorzh S., Purev L., Laihansuren B., Mining Engineer's Handbook-8. Economics, business and mining management. UB. 2012.

[13] Raymond L. Lowrie P. E. Mining Reference Handbook. SME. Colorrado, USA. 2002.

[14] Sumenkov M. S, Kislyak V. M. Chichkanov V. P, Optimal planning of the activity of industrial enterprises. M., 1980.

[15] Turbetskoy K. N, Potapov M. G, Vinitsky K. E, Melnikov N. N and others. Open Pit Handbook. M. Mountain Bureau, 1994.

[16] Fisenko G. L. Stability of the slope of open pit and dumps. M., Nedra, 1965.

[17] Howard L. Hartman. Mining Engineering Handbook. SME. Colorado, USA. 1992.

[18] Tsedendorzh S., Purev L. Fundamentals of mining technology. UB. 2005.

[19] Tsedendorzh S., Purev L., Laihansuren B., Haidav A., Mining Engineer's Handbook-5. Open Pit Technology. UB. 2011.

[20] Yumatov B. P. Technology of open pit operations with combined development of ore deposits. M., Nedra, 1966.