

***Tyumen Oil and Gas Forum,
September 17-19, 2019***

***Andrey Kochergin
CEO, LLC Expert of Subsoil
expertnedr@gmail.com
+7-916-380-55-45***

Improving the audit of solid mineral resources



1. New classification of reserves and forecast resources of solid minerals

Presidential
order -
creating a
new
classification
of solid
minerals

“A new classification of reserves should be developed and approved as close as possible to international standards”

Vladimir Putin February 13, 2013



On February 13, 2013, in Novo-Ogaryovo, at a meeting of the FEC Commission, President Vladimir Putin instructed to develop a new classification of TPI reserves.

“Due to the archaic nature of our reserves assessment system, the domestic resource base is underestimated. This directly affects the investment attractiveness of domestic energy companies. Obviously, market participants - mining companies, investors - must possess not only reliable data on the volume of mineral reserves. Our natural assets must have reasonable, understandable and objective value. ”

2. Comparison of the draft new Russian classification of reserves of TPI with CRIRSCO

Object of assessment		Mineral deposits			Geological manifestations and areas			
Groups of mineral deposits by degree of study		Exploited mineral deposits	Explored and prepared for development mineral deposits	Estimated and prepared for exploration and pilot work	Predicted and Estimated			
		Basis of operational and ongoing mining planning	Calculated by constant exploratory conditions. Basis for mining design	Calculated by temporary conditions. The basis for deciding on the feasibility of further work				
Basis for starting work		The technical project for the development	Exploration Project	Appraisal Project	Exploration and appraisal project			
Categories of mineral reserves by degree of geological knowledge	Russia	Geological reserves			Forecast Resources			
		B	C1	C2	P1	P2	P3	
	CRIRSCO	Mineral Resource (минеральные ресурсы)			Prepared (inferred)	localized	promising	
	Measured (оценённые)	Indicated (выявленные)						
	Recoverable (operational) mineral reserves (taking into account dilution and subsoil losses)							
	Russia	Evaluated by the parameters of the technical project for the development of mineral deposits						
		R ₁	R ₂					
	CRIRSCO	Mineral Reserves (запасы)						
	Proved (доказанные)	Probable (вероятные)						
Economic importance	Russia	Balance reserves (экономические); Off balance reserves (потенциально экономические).						
	CRIRSCO	Economic (only for Mineral Reserves); Potential economic (only for Mineral Resource)						
Group of complexity	Russia	By the complexity of the geological structure of mineral deposits - group 1, group 2, group 3, group 4			CRIRSCO template does not provide predicted resources			
	CRIRSCO	Not stand out			3			

3. State and commercial assessment of reserves of TPI

Reserves are mineral resources of value ($NPV \geq 0$)
Mineral resources are potential reserves ($NPV < 0$)

State valuation of reserves takes into account profitability (cost), but does not take risks into account (although in the current Russian classification, risk accounting goes through the group the complexity of the geological structure).

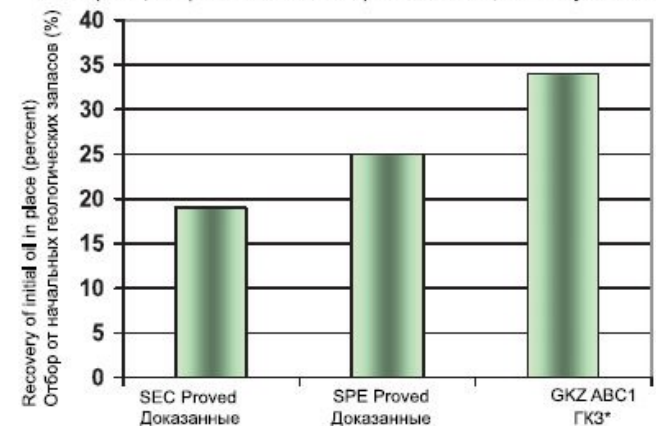
In fact, state. reserve assessment is an assessment of the georesource potential of a field, assessment of mineral resources.

Commercial valuation of mineral reserves takes into account profitability (cost) and partially takes into account risks using qualitative methods

Reserves are allocated from resources based on an analysis of profitability and risks (modifying factors). Quantitative accounting of risks can only be in the transition from deterministic to probabilistic methods for calculating reserves. So the oil workers have already done.

State appraisal of mineral reserves is always higher than commercial !!!

Fig. 2 International proved reserves vs. GKZ for Russia
Рис. 2 Сравнение категорий запасов: доказанных запасов по международной классификации с российскими категориями запасов, используемых ГКЗ



* Data from DeGolyer & McNaughton – 2004
* Данные взяты из материалов компании DeGolyer & McNaughton – за 2004 год

4. The state examination of mineral reserves does not take into account the impact on their value of categories of reserves and stages of economic evaluation

When assessing the cost-effectiveness of options, the feasibility study of conditions and industrial development projects do not take into account the geological risks associated with the degree of exploration of the subsoil area (reserves of categories A, B, C1, C2), in contrast to the calculation of the starting one-time payment for licensing



Change in the selling price of a subsoil plot during licensing, depending on its degree of exploration (accounting for geological risks)

The empirical formula for transferring resources to reserves when calculating one-time (starting) payments

$$ABC = A + B + C1 + 0,5 \cdot C2 + (0,25 \cdot P1 + 0,125 \cdot P2 + 0,0625 \cdot P3) \quad (1)$$

5. How to digitize the rational use of mineral resources?

State evaluation criterion

Clause 5, Article 23 of the Law on Subsoil: "The most complete extraction from the subsoil the main reserves and, together with them, the occurring mineral resources and associated components."



Article 23.1 "State regulation of the relations of subsoil use and the solution of the problems of developing the mineral resource base are carried out using geological, economic and cost estimates of mineral deposits and subsoil areas. The methods of geological, economic and cost estimation of mineral deposits and subsoil sections by types of minerals are approved by the federal governing body of the state subsoil fund."

The most complete extraction from the subsoil of value

Public
Budgetary
Commercial

Value

Criterion: $NPV_{\text{budgetary}} = \max$

6. The paradox of the CRIRSCO classifications (why can not the category inferred be transferred to reserves?)

1. Reserves are resources whose extraction allows the investor to earn income. This is where NPV Scheduler is based.
2. Therefore, in terms of valuation:
3. If $NPV \geq 0$ are reserves, $NPV < 0$ are resources
4. Inferred category according to the CRIRSCO template cannot be assigned to reserves. But practice refutes this thesis. Resources on the exchange have value - this is what the entire junior movement in geology holds for. So the inferred resources are partly reserves (see the formula for transferring forecast resources when calculating starting (one-time) payments.
5. Category C2 may or may not be reserves. In each case, it is necessary to calculate NPV taking into account the risks, then draw a conclusion about the balance sheet ownership.

7. Quantitative Revolution in Valuation of Solid Mineral Reserves - An Inevitable Perspective

“The term” mineral reserves “as used by an engineer, financial director, banker and financial analyst means a reliable, reliable value. Terms such as "proven", "probable", "possible", "developed" and "undeveloped" define categories of reserves characterized by varying degrees of confidence in their existence. The main problem when using these terms is that there is no reliable criterion for allocating reserves of these categories, except for such a vague verbal criterion as "sufficient reliability". A more preferred numerical expression of this confidence in terms of probability is required.”



Peter R. Rose. Risk analysis and management of oil and gas exploration projects

8. National Valuation Codes



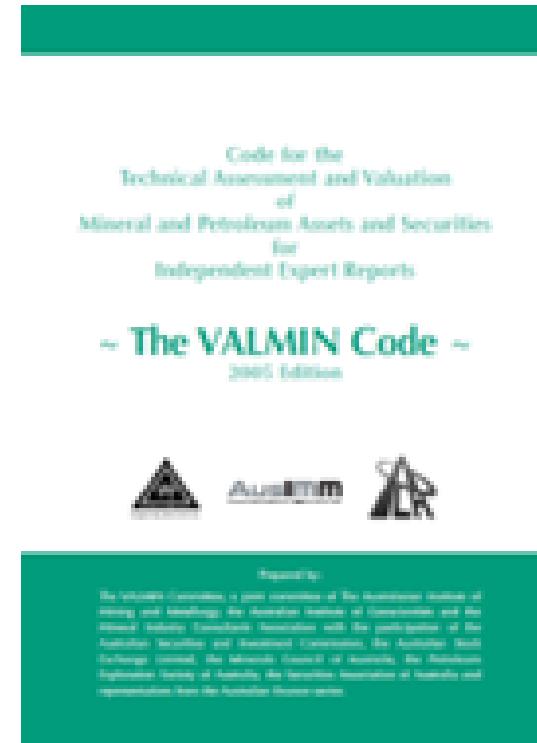
International inventory valuation standards are always paired with national valuation codes:

Australia – Jorck/Valmin

Canada – NI 43-101/CIMVAL

South Africa –SAMREC/SAMVAL

Russia – NAEN Code/?



9. Cost is a universal criterion in assessing useful reserves

1. The main criterion for the allocation of mineral reserves is the cost (NPV)

Mineral reserves are tangible assets of value ($NPV \geq 0$). When developing them, the investor will receive income. Reserves are allocated from mineral resources at the stage of economic (value) valuation

mineral resources. Therefore, it is not clear why in the current Russian 2006 classification reserves and forecast resources exist separately from each other.

2. Categories of mineral reserves differ in the probability of obtaining value (income).

The probability of generating income may be, for example, 90, 50 and 10% (see hydrocarbon classification

- SPE-PRMS). The SEC Oil Classification, on the basis of which all world investment institutions (banks, exchanges) grant loans or accept stock price calculations, only reserves with a 90% probability are recognized).

Mineral reserves classification:

- **proven p90 ($p \geq 90\%$)**
- **probable p50 ($p \geq 50\%$)**
- **possible p10 ($p \geq 10\%$)**

Concept study: **$\pm 30\%$**
Pre-feasibility study: **$\pm 20\%$**
Feasibility study: **$\pm 10\%$**

The accuracy of the economic assessment of mineral reserves depending on the stage of assessment (according to Kaputin Yu.E.) (taking into account economic risks)

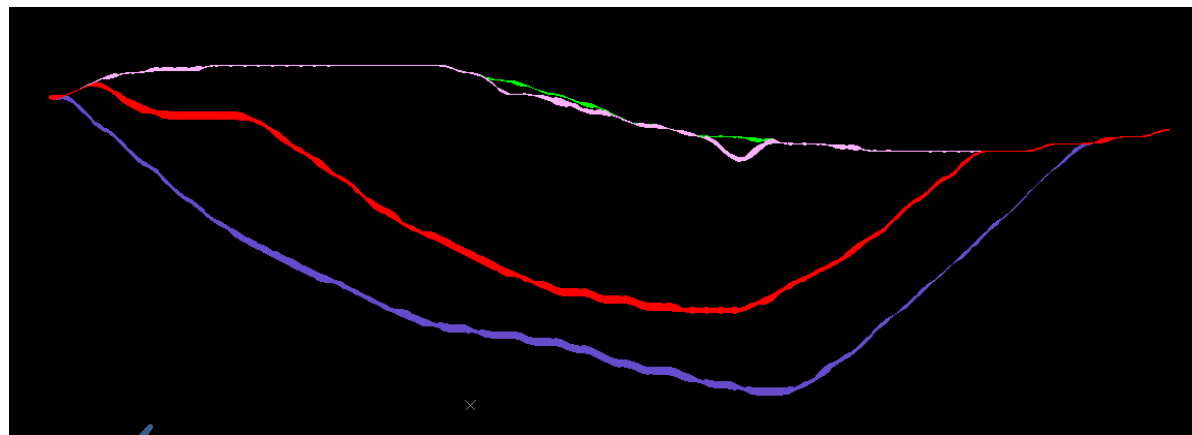
The probability of estimating reserves is determined taking into account geological, economic risks, and risks of modifying factors

10. An example of valuation of field reserves: optimization of open pit boundaries using the NPV Scheduler program

Lurch-Grossman Algorithm

It is widely used to determine the ultimate boundaries of a quarry. Optimality criterion (objective function) - max NPVcom

Investigates cash flows cash flour (cf) and maximizes them



NPV scheduler –оптимизация границ карьера

Pit	Price	Rock	NPV	ore
		tonnes	\$	tonnes
Pit 1	30,00%	28 537,00	29 320 790,00	25 305,00
Pit 2	40,00%	396 415,00	263 087 663,00	312 095,00
Pit 3	50,00%	2 997 190,00	1 087 738 571,00	1 885 825,00
Pit 4	60,00%	25 625 826,00	4 996 516 982,00	14 199 720,00
Pit 5	70,00%	33 104 596,00	3 708 785 248,00	15 622 823,00
Pit 6	80,00%	550 058 811,00	6 724 261 129,00	127 412 800,00
Pit 7	90,00%	183 480 248,00	565 788 020,00	37 329 760,00
Pit 8	100,00%	93 495 883,00	67 859 684,00	16 300 870,00
Pit 9	110,00%	33 871 314,00	-24 867 331,00	5 336 840,00
Pit 10	120,00%	25 385 029,00	-45 237 499,00	4 300 240,00
Pit 11	130,00%	17 327 864,00	-39 938 013,00	2 250 355,00
Pit 12	140,00%	34 814 498,00	-94 103 582,00	3 827 330,00
Pit 13	150,00%	13 491 526,00	-45 390 794,00	1 616 645,00
0		01 014 077 738,00	17 193 820 868,00	230 420 608,00

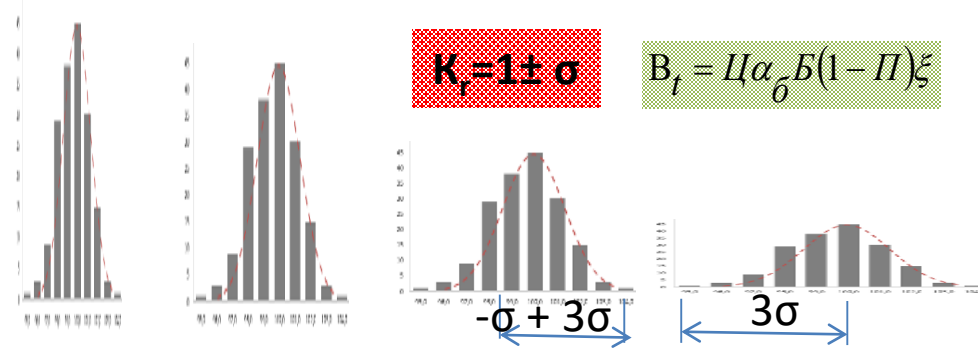
Rapid valuation of the field (using NPV scheduler as an example — optimization of open pit boundaries)

11. Quantification of risks in the valuation of reserves and resources (proposed approach)

1. Quantitative methods for classifying reserves and mineral resources by cost criterion:

$$\text{ЧДД(NPV)} = \sum_{t=0}^T B_t K_{\text{геол}} \frac{1}{(1+E)^t} - \sum_{t=0}^T \left((K_t + 3_n) K_{\text{гэ}} \frac{1}{(1+E)^t} \right)$$

Mineral reserves - mineral resources of value (NPV ≥ 0)
 Mineral Resources - Potential Money (NPV < 0)
 The cut-off grade is determined by solving the equation NPV = 0 (now Profit = 0)



2. Consideration of geological and economic risks in assessing reserves (mineral resources) and their value (probabilistic methods)

When calculating the value of reserves, introduce decreasing coefficients when calculating income (inflows) and increasing coefficients when calculating expenses, depending on the category of reserves exploration and the stage of geological and economic assessment of the field

A

±15-20%
 $\sigma = (15-20\%):3 = 5$
 -5,8%
 (average 5,4%)

B

±20-30%
 $\sigma = (20-30\%):3 = 6,7-10\%$
 (average 8,4%)

C1

±30-60%
 $\sigma = (30-60\%):3 = 10-20\%$
 (average 15%)

C2

±60-90%
 $\sigma = (60-90\%):3 = 20-30\%$
 (average 25%)

Interval $-3\sigma + 3\sigma - p = 99.7\%$

Interval $-2\sigma + 3\sigma - p = 97.6\%$

The interval $-\sigma + 3\sigma - p = 84\%$ - was taken for calculations



12. Calculation of the amount of harm (loss) from lost mineral reserves

Decree of the Government of the Russian Federation of July 4, 2013 N 564 "On approval of the Rules for calculating the amount of damage caused to subsoil due to violation of the legislation of the Russian Federation on subsoil" contradicts the income method of determining the value of reserves (costs and discounts are not taken into account)



The value of mineral reserves lost as a result of harm caused, including pollution of the subsoil, flooding, fires, as well as unauthorized use of subsoil, is determined by the formula:

$$L3 = Nbz \times P, *$$

where: Nbz - the amount of mineral reserves lost as a result of harm ... reduced by the value of the norms of technological losses approved in the established manner
 P - the cost of a unit of mineral, determined by the average market price of its sale for 6 months preceding the date of the offense (rubles)

r^* - mineral reserve calculation error

Name	Deterministic Evaluation	Probability assessment			
		A ($r^* \pm 10\%$)	B ($r \pm 20\%$)	C1 ($r \pm 30\%$)	C2 ($r \pm 50\%$)
Geological risk factor K_r	1,00	0,97	0,93	0,90	0,83
Lost ore reserves, mln tons	183,6	178,1	170,7	165,2	152,4
The amount of harm, billion rubles.	165,6 / 2,4	2,1	1,8	1,6	1,0

13. Priority steps

1. *Consolidate intellectual centers of competence by creating a National Training Center for Subsoil Use and a national certification system. As teachers use practitioners from the best corporate training centers (Polymetal, Lukoil, etc.)*
2. Conduct an upgrade of the NAEN Code and create a National Standard and Audit Recommendations in Subsoil Use
3. To develop training and certification programs for the National Training Center, including those according to the National Standard. To train qualified specialists in the geological industry and conduct their certification.
4. To ensure demand for specialist services, launch a specialized venture investment platform on the Moscow Exchange. Rosnedr (30-50 billion rubles per year) part of the flow of auction sales of licenses to redirect to the exchange, which stabilizes exchange trading. Around the exchange, communities of consultants, appraisers, etc. will be formed. The NAEN Code, the Valuation Code, and the Russian State Sanitary Inspection will be in demand.
5. *Introduce the NAEN Code into the state examination of reserves*



ГКЗ



THANKS FOR YOUR ATTENTION!