MINERAL RESOURCE AND ORE RESERVE ESTIMATION

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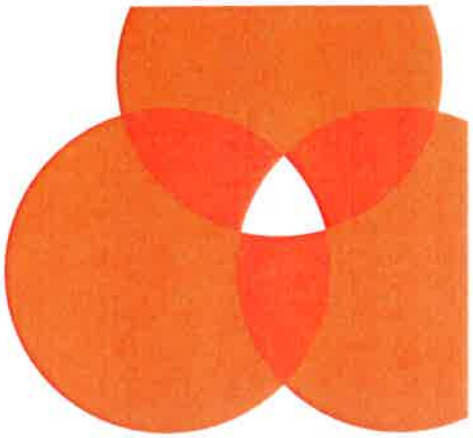

Resource and Reserve Valuation Practices in Countries Forming the Russian Commonwealth of Independent States

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ABSTRACT

Russia has increasingly become one of the more important centres for activities on raw commodity assessments in recent years due to its significant resources over a huge territory. As Russia rapidly closes the gap between the requirements of the internationally accepted codes and its own resource assessment standards, the practical reality is that the Soviet Union legacy of assessing resources is still active today. This does not mean that the requirements of the old Soviet system – now the Russian system – are redundant or unacceptable globally; rather it is a descriptive and useful tool that guides Competent Persons and practitioners in a well-prescribed way when assessing Mineral Resources in Russia. As the old Soviet standard has also been adopted by the national legislations in other former Soviet Union countries, the Russian code has become an important element in reconciling resources in accordance with criteria defined in internationally recognised codes for reporting Mineral Resources and Ore Reserves such as JORC. This paper reviews the experience of IMC (International Mining Consultants) Group Consulting Limited in resource estimation in both Russia and neighbouring countries that form the Commonwealth of Independent States (CIS) in regards to complying with both national and international codes as well as the related issues and obstacles faced by Competent Persons.

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INTRODUCTION

Raw commodities in Russia have always been treated as strategic national assets owned collectively by the people and its legal representative by the State. This is also due to both the development history of the Russian system of Mineral Resource estimation and the Russian constitution that specifies the state monopoly of subsurface ownership. For this reason, very strict rules and controls have been in place to ensure that the value of those resources are maximised for the benefit of the nation. A set of standards under the Russian National Standards (GOST), as well as many state regulations, were allocated for the purpose of how the resource characterisation should be conducted at every level according to the prescribed methodology. This means that the system is based on well-defined criteria for every activity in the assessment process, leading to a final outcome for the allocation of resources and reserves without any subjectivity.

As the current resource and reserve assessment system has been inherited from the Soviet Union, many of its fundamentals still resonate with this legacy. This means that companies interested in extracting raw materials have to undergo several steps in the assessment process to delineate, quantify and qualify the mineralisation in the ground. Each of these steps is controlled by independent state organisations to ensure that mineralisation boundaries are well defined and resource use is optimised.

As Russia is effectively providing the world economy with a significant portion of raw commodities, it is important for western companies to understand how the Russian resource classification and reporting system operates, and what the similarities and differences are between the Russian system and internationally accepted codes such as JORC.

It must also be noted that in 2011 Russia became a member of CRIRSCO (Committee for Mineral Reserves International Reporting Standards), the umbrella organisation for well-known standards such as JORC and NI43-101. The Russian national code (the 'NAEN Code') has now been developed by the Society of Experts on Mineral Resources (OERN, a component body of NAEN) in close cooperation with the State Commission on Reserves (GKZ) and members of CRIRSCO (CRIRSCO - NAEN, 2011). The NAEN Code is modelled closely upon the CRIRSCO International Reporting Template.

STAGES OF GEOLOGICAL AND ECONOMIC EVALUATION OF RESOURCES IN RUSSIA AND COMMONWEALTH OF INDEPENDENT STATES COUNTRIES

By law, Russia and other CIS countries use the classification system and estimation methods for reserves and resources

established by the former Soviet Union. In practice, this means that the statements of reserves and resources developed by the mines to which they relate must be approved by the corresponding committees of the government authorities. Adherence to the standardised national system of reserves and resources estimation is mandatory.

Geological exploration and development of mineral deposits in Russia and CIS countries is licence-based, with such licences granting the private subsurface users the exploration and mining rights within the defined concession areas. The licences are generally issued for 20 - 25 years (subject to extension) based on open tender or auction results. There are three types of licences: geological exploration, production of minerals and both production and subsoil exploration. Geological and economic evaluation of the concession should comply with requirements set by the federal agency for management of the State subsurface fund regulating procedure and methodology of evaluation work.

Regulatory documents in this system provide clear criteria for borehole grid spacing that relates to deposit complexity when classifying the deposits. These detailed procedures are also extended to technical and economic evaluation of the deposits. The latest edition of the Russian classification system even specifies the numerical values of requirements for possible confidence levels in estimating geological parameters characterising a reserve.

The system serves a number of purposes ranging from taking Mineral Resource inventories to statistical reporting and estimation of mineral extraction taxes to other state regulatory objectives. Due to its transparent and unambiguous nature in categorising the reserves, in many respects the Russian system is particularly ideal for a geologist as it clearly characterises both resource and economic potential of the deposits from the Russian perspective. In essence, it is a package of documents collected at various stages of geological and economic study of the deposit that describes and evaluates the deposit's geological features and mining characteristics thoroughly.

Each stage of geological exploration is related to a certain technical and economic evaluation describing the most efficient and safe mining methods and corresponding production of optimum saleable products. The general framework of the geological characterisation for any mineral deposit is given in Table 1.

Some stages of geological and economic evaluation of the deposit in this table are not mandatory and can be bypassed in certain circumstances. In particular, due to the reasons related to the general circumstances, development of operational cut-off parameters is at the initiative of the subsurface user; for example, significant changes in general economic conditions, important changes in original geological information based on advanced operational exploration and deposit development or the need to introduce new machinery and technology for the operations. In some cases, provisional cut-off parameters may also be adopted by comparing neighbouring deposits without a tailored technical and economic analysis due to similarities that may exist between the two situations.

HISTORICAL DEVELOPMENT OF RESOURCE AND RESERVE ASSESSMENT IN RUSSIA AND ITS GENERAL PRINCIPLES

In the prerevolutionary period and until the 1930s, Russia/Soviet Union used a system of reserve classification based on explicit expression of categories broken down into 'actual', 'probable' and 'potential' classes; however, this was not accompanied by a clear-cut criteria for classification and this brought about an arbitrary interpretation of available reserves. For this reason, in the early 1920s a special commission of the USSR Geological Committee started work aimed at developing criteria describing the deposits more clearly, both in terms of precise geological information and their economic significance. As a result of discussions in 1928, the Geological Committee adopted a reserve evaluation system based on the use of letters. In this system, the reserves were classified into letter categories on the basis of geological knowledge and their economic use: A_1, A_2, B, C_1, C_2. It should be noted that substitution of the above categories (actual, probable and potential) by letter-based classes was proposed as early as 1910 at the 11th session of the International Geological Committee in Sweden.

TABLE 1
General framework of the geological characterisation of mineral deposits.

Study stage	General task	Scope of work and deliverables
Stage I – Common geological and mineralogical work	Regional geological study of subsurface and prediction of mineralisation	Regional geological and geophysical survey. Identification of promising sites for prospecting.
Stage II – Prospecting and evaluation of deposits	Greenfield exploration	Exploration of basins, ore districts, fields, etc through geophysical surveys, single boreholes and workings. Estimation of prognostic P_1, P_2, P_3 Resources. Technical and economic considerations of ore occurrence prospects.
	Prospecting (including preliminary exploration)	Geological survey of a prospective deposit at a far-spaced grid of boreholes and workings. Evaluation of general parameters of the deposit, configuration and size of orebodies, technological properties of ore, hydrogeological conditions, etc. Qualitative and quantitative evaluation of prognostic P_1 Resources, C_1 and C_2 Resources. Technical and economic report or technical and economic proposals. Technical and Economic study (TEO) of provisional cut-off parameters and recording Reserves on the state balance.
Stage III – Deposit exploration and development	Detailed exploration	Drilling of a closely-spaced borehole grid sufficient for the most detailed study of geological and technological properties of ore and the most accurate estimation of the economic potential of the deposit. Classification of A, B, C_1 and C_2 Reserves. TEO of final cut-off parameters with GKZ re-approval of Reserves on the state balance.
	Mine operations	Operational exploration in the process of mining operations aimed at detailed study of the subsurface required for current mine planning. Development of operational cut-off parameters.

Later, the Russian system of classification was repeatedly revised with a view to improving reference to geological knowledge and economic significance of deposits. Along with refining and improving the system of reserve classification, work was undertaken to develop regulatory and legal documents and guidelines for estimating reserves for deposits of various types and complexities.

As a result of these revisions, the basic principles of the reserve classification system currently in operation in Russia were formulated by 1981, revised later in 2008. According to this system, a mineral deposit is defined as a natural or man-made concentration of a mineral, development of which may bring about economic benefits. In its turn the term 'reserve' covers an identified quantity of a mineral, part of which may be extracted economically into seven categories: explored (solid Mineral Reserves of categories A, B, C_1) and pre-evaluated reserves (C_2) and prognostic resources (P_1, P_2, P_3) based on the degree of reliability of exploration data. A brief description of the categories is given in Table 2. In addition, every ore deposit in Russia and CIS countries is also grouped according to its complexity in a numbering system ranging from I to IV (III for coal deposits) (Table 3).

Under this classification system and current reporting regime, reserve categories are allocated based on a set of conditions for estimation of reserves prepared as part of the exploitation licence for each mineral deposit by the corresponding special professional organisations (institutes, engineering organisations, etc) and are approved by the State supervisory authorities.

Upgrade to C classes from P requires additional data (typical Modifying Factors such as geotechnical, economic, pit design, etc) whilst C_1, B and A classes require completion of a Pre-Feasibility/Feasibility Study, which is generally called the 'TEO of conditions' (technico-economicheskoye obosnovaniye kondicy, which stands for technical-economic justification of minimum parameters). The publication of data in the above classes requires audit and registration by an independent organisation; ie GKZ (Gosudarstvenaya Komisiya po Zapasam, which translates to State Commission on Reserves) at the national level or TKZ (Teritotorialnaya Komosiya po Zapasam or Territorial Commission on Reserves) at a regional level. Expert opinions from these organisations are given by a group of highly qualified specialists in various disciplines including geology, mining, environment, processing, hydrogeology, economics, etc. In the course of preparing GKZ expert opinion, experts may introduce changes into the 'TEO of conditions' related to mining technology, processing solutions as mistakes may be found in interpretation of geological data, projection of the

TABLE 2
Reserve categories in Russian and Commonwealth of Independent States systems.

Category	Description
A	Deposit is known in detail, boundaries of the deposit have been outlined by trenching, drilling, or underground workings. Quality and properties of the mineral are known in sufficient detail to ensure the reliability of the projected exploitation.
B	Deposit has been explored but is only known in fair detail, boundaries of the deposit have been outlined by trenching, drilling, or underground workings. Quality and properties of the mineral are known in sufficient detail to ensure the basic reliability of the projected exploitation.
C_1	Deposit has been estimated by a sparse grid of trenches, boreholes or underground workings. The quality and properties of the deposit are known tentatively by analogy with known deposits of the same type and the general conditions for exploitation are known tentatively. This category includes Resources peripheral to the boundaries of the A and B category and also Reserves allocated in complex deposits in which the mineral distribution cannot be reliably determined even by a very dense grid.
C_2	Extent of the deposit has been extrapolated from limited data. This category includes Resources adjoining areas designated as A, B and C_1 in the same deposit.
P_1	Resources in the P_1 category may extend outside the actual limits of the mineral Reserves defined in the C_2 category. The outer limits of P_1 type Resources are determined indirectly by extrapolating from similar known mineral deposits in the area. P_1 is the main source from which C_2 Reserves can be increased.
P_2	These Resources represent possible mineral structures in known mineral deposits. They are estimated based on geophysical and geochemical data. Morphology, mineral composition and size of the mineralisation is estimated by analogy with similar mineralised geological structures in the area.
P_3	Potential for discovery of a deposit of any type of mineral on the basis of favourable geological and indicative preconditions found in the prospective area by undertaking medium to small-scale geological and geophysical surveying, satellite image interpretation and analysis of geophysical and geochemical survey results.

TABLE 3
Classification of deposits according to their complexity in Russia and countries that form the Commonwealth of Independent States.

Complexity type	Description
I	Large deposits, simple in form with uniform distribution of minerals. The highest confidence classes of Reserves, A + B Reserves, can be established on the basis of boreholes, trenches and trial pits.
II	Large deposits with variable and sometimes complicated forms and an uneven distribution of minerals. Only B and C_1 Reserves may be defined based on exploration data, such as boreholes, trenches and pits and higher confidence Reserves classes can be established only by a combination of closely-spaced boreholes and active exploitation.
III	Deposits are smaller in size with uneven distribution of minerals (examples include vein-hosted or pegmatite deposits, skarns and dykes). Only C_1 and C_2 Reserves may be defined based on exploration data and higher confidence Reserves classes can be established only on the evidence of operational experience.
IV	Complex geological structure with small or rarely medium-sized orebodies with exceptionally uneven mineralisation or characterised by sharp variations in thickness and internal structure, extremely uneven mineral quality or grade and intermittent concentrations of the main useful constituents. Deposits of this group are explored primarily to Russian Resource category C_2, with confirmation of reliability of their estimation, in areas of detailed study, at category C_1.

cash flow model, etc. As a result, the changes may influence the classification of reserves into a different category, hence affecting the totals stated.

The TEO document is comprehensive and detailed and covers the geological and technical/technological assessment and economical evaluation of the deposit in question for different cut-off parameters. It also checks the suitability of the chosen mining methodology for the current health and safety legislations and procedures in place. The economic assessment typically investigates the different cut-off parameter options defined from the geological and technological perspectives under the headings of: analysis of market and economic environment and taxation issues, operational cost and production cost and product sales, capital costs, floating capital investments, profitability, discount rate, net cash flow and net present value, internal rate of return and economic indicators.

The main distinctions between these documents are based on their individual objectives. If the main criterion in developing Pre-Feasibility and Feasibility Studies is investment attractiveness of the deposit (in some cases even to the detriment of the reserve quantity), a TEO of conditions shall justify solutions that imply maximum full recovery of reserves with a view to satisfying the balance of interests of the State and of the subsurface user.

With reference to these conditions, the reserves stated for each deposit are further categorised as 'balance reserves'; this means that they meet the predetermined criteria for economically justifiable extraction or 'out-of-balance resources', which are considered to be presently uneconomic to exploit, but potentially economic in the future. Another category of reserves under the current system is the 'industrial resources/reserves' category, which forms the 'balance reserves' after adjustments for all operational losses. Industrial reserves take account of dilution (contamination) and form exploitation reserves, which fully characterise the commercial significance of the deposit. Estimation of both industrial and exploitation reserves is made at the TEO of condition' stage and at the detailed engineering phase.

It is important that any resource be approved by GKZ or TKZ before mining is allowed. Therefore the cut-off parameters document is crucial in finalising approval of the reserves. GKZ/TKZ approval also includes transfer of reserves to the national mineral inventory or the State 'balance' of reserves. The former Soviet system places all the available mineralisation in the ground as a reserve based on the cut-off parameters defined and does not make any distinction between the resource and reserve.

The typical flow of exploration and deposit characterisation – as well as the related technical and economic studies for exploiting the reserves in Russia and CIS countries – is given in Figure 1.

CONVERSION OF RUSSIAN CATEGORIES TO THE CRIRSCO TEMPLATE

There were many attempts to convert Russian resource/reserve categories to those defined by CRIRSCO-aligned standards in the past.

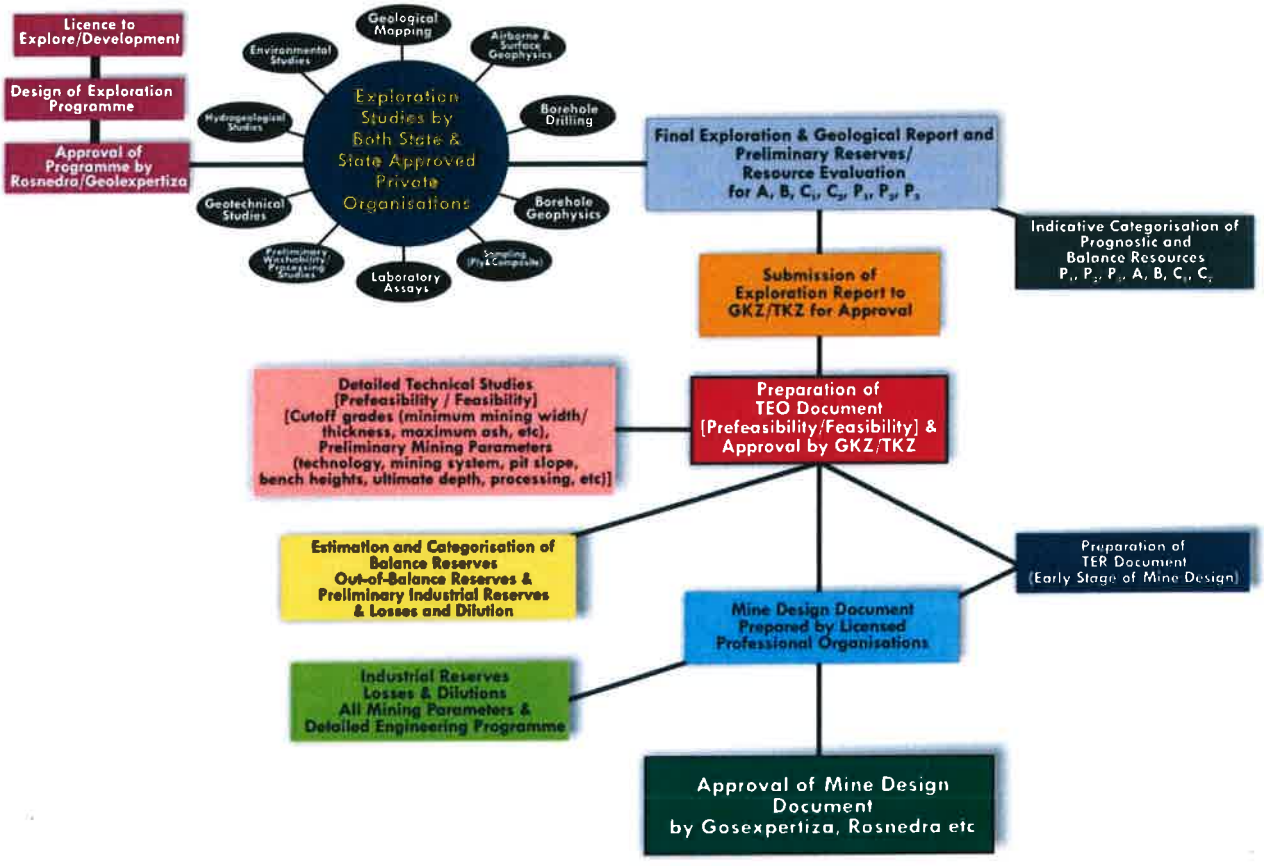

FIG 1 - Simplified framework of resource/reserve assessment in Russia and countries that form the Commonwealth of Independent States.

In 2010, a working group of experts from FGU (Federalnoye Gosudarstvenoye Uchrezhdeniye), GKZ, CRIRSCO, mining and other companies and Russian and international universities prepared detailed guidelines on converting the Russian minerals reporting standards into the CRIRSCO International Reporting Template directly.

The final version of this document (FGU-GKZ and CRIRSCO, 2010) indicated that the general assumption in the recent past was that in order to produce a CRIRSCO-aligned report on a Russian mineral project, it was necessary to work from the base raw data and carry out a completely separate modelling and estimation exercise. As the fundamentals can be significantly different in allocating the resource and reserve categories in each system (ie Russian- and CRIRSCO-based templates), this could produce a set of estimates for resources and reserves that cannot be easily reconciled with the Russian estimates. This leads to many problems for companies, both with the authorities in Russia and with the stock markets around the world.

It is important, however, to emphasise that non-Russian specialists still need to have a high level of understanding of the Russian classification system in this conversion process. These guidelines have been developed primarily on the basis of the respective definitions (rather than on individual experiences of different projects) and are applicable to all types of solid mineral deposits. The working group guidelines document also emphasises that every deposit is different and these are only guidelines, not instructions. Therefore the Competent Person should not apply the guidelines mechanically and instead provide the same degree of justification for the resulting classification as in producing any other CRIRSCO-compatible report.

MAIN CHALLENGES

There are many challenges when applying both the Russian system and internationally accepted codes in Russia. The following list is a small sample based on IMC's past and recent experience in both Russia and other CIS countries.

Borehole coordinates and other geographic information systems information

As the Mineral Resources in Russia and other CIS countries have traditionally been treated as strategic assets, the secrecy on GIS (geographic information systems) information still continues today. Many mines in Russia and other CIS countries continue to operate with false coordinates for topographic maps at 1:50 000 and smaller scales dictated and regulated by the national laws and local regulations; only a few people at the mines (as in the mine director, mine geologist and chief surveyor) have access to the true coordinates If necessary, the false coordinates can be converted back to the true coordinates through specially issued codes by the chief surveyor for official documentations such as licensing details. In some isolated cases, mine management would still be reluctant to release even the false coordinates to the outside world. This is especially true for foreign experts operating in Russia as releasing the data to the foreigners can be a punishable offence.

IMC's experience with clients is to both respect the local rules and regulations and to accommodate the requirements of the JORC-based assessment while ensuring that all information in the documents (maps, plans, cross-sections, etc) based on false or true coordinates are truly represented. This means that foreign experts are usually given full access to the original records for inspection but are not allowed to make any copies. It should be noted that Vladimir Putin, the President of Russia, set forward an initiative in 2013 to make preparation of reserve and resource estimates under international standards easier, specifically regarding the secrecy on GIS.

Data availability and access

In many cases, the known mineral deposits in Russia and other CIS countries are investigated in detail through well-documented exploration programs and technical studies. The amount of information accumulated over decades is sometimes so overwhelming that reviewing or inspecting the volumes of data and reports can easily take weeks and months; however, in many instances the original data is not kept at the mine site, as it is state owned and looked after by the state geological trusts spread around the country. The data held by these institutions include all the necessary documents on any deposit under their jurisdiction, such as original borehole log books, exploration reports and other technical Pre-Feasibility and Feasibility Study documents usually in paper format. The mining companies purchase this data from the state geological trusts or the 'Rosegeofund' if they need the original data on the deposits for further evaluation. Then copies are made from the originals and preserved at the mine sites and headquarters of companies. These copies may be in paper format or digitally scanned. Plans, maps and cross-sections from previous studies are sometimes digitised and stored as picture files where they are utilised as rasters (images) in appropriate software if necessary. Some of the data is available in spreadsheet format.

In some instances, IMC-competent persons visit the geological trusts and consult the original reports as well as other technical experts who would know the specific issues on that particular deposit.

The borehole drilling from Soviet times consisted of both open hole and core drilling with some geophysical logging in the later phases of investigations. Borehole deviation measurements were also standard. Borehole geophysical logging (eg at least natural gamma, density, sonic and calliper) was undertaken in the majority of boreholes; for example, to determine the coal seam thickness and its continuity. According to the existing technical documentation on many sites, the core recovery in the majority of cases is more than 80 per cent, which was acceptable under the Soviet standards; however, during Soviet times the teams were still encouraged to provide higher core recoveries by offering bonuses. Borehole core photography was not a common practice in Soviet times and is still yet to be implemented in many current exploration projects. Therefore, for old geological studies the chance of finding any core photographs is low.

IMC's experience with local mine expertise and management is that full cooperation is generally provided to the consultant and open discussions on the geological and mining issues are held without any problems. The local teams at the mine operations can be very honest about their difficulties and are always eager to hear different solutions and approaches. Still, in some remote locations the mine personnel can be less accommodating if the purpose of the visit is not explained to the local teams by company headquarters who wanted the JORC-based assessment in the first place. This can be

rectified through a consultation process with various parties at headquarters and data access is later provided without any problems.

Manual estimation versus automated estimation

In many cases, the manual estimation of resources is still the only methodology used to estimate Mineral Resources. In this manual methodology, every individual block is delineated and coded on the basis of its geological characteristics, which are all well documented.

The conditions defined by the GKZ for estimation of reserves for each deposit specify the method of computation of reserve blocks, cross-sections, etc; the minimum geometry parameters for exploitation of the minerals (eg minimum coal thickness) and cut-off parameters (eg maximum ash content for coal grades); plus special considerations that may apply where the conditions for mineral extraction are exceptional or present difficulties.

For example, mineral deposit volumes can be estimated by determining the areas at specific levels and multiplying this area by the average thickness estimated from sections through the applicable area. The estimate of resource tonnage is obtained by multiplying the estimated volume by the assumed or determined specific gravity (SG) defined in the TEO of Conditions (Conditions for Estimation of Reserves) for each deposit for specific mineral type and grade.

The use of geological and other mining packages has recently found more acceptance at the mine sites although there is still a long way to go for a full recognition of the benefits of these packages. One of the reasons for this could be that only State-registered and State-approved computer packages are allowed to be used in resource and reserve estimations. The process of approval through the official channels for these packages can be tedious and lengthy.

Nevertheless, in-house expertise at GKZ institutions is rapidly catching up in using such software. As a result, geological exploration materials that are prepared using 3D geological and mining modelling as well as estimation of resources prepared in preapproved packages after verification have been finding more acceptance.

The companies that realise the benefits of these software packages can also argue their cases to the appropriate authorities in the hope of modifying some of the cut-off parameters conditions dictated by the State organisations earlier. To do this they develop parallel resource estimation for internal usage and demonstrate the benefits of using the geological and mining package to the official authorities. IMC has been asked by many of its clients to create a model for their needs or to verify that the general modelling principles of company-created models have been applied correctly.

Mindset between resources and reserves

In Russia and CIS countries all resources are technically regarded as reserves with different levels of categories attached to them, such as balance reserves (economic reserves), out-of-balance reserves (potentially economic reserves) and industrial and exploitation reserves (extractable tonnages after losses and dilutions). If some portions of the balance reserves cannot be extracted from the ground, the companies have to prepare very detailed technical and economic justification reports demonstrating why these portions of the mine site cannot be mined to the authorities. This can sometimes be a relatively costly exercise to undertake.

The Soviet system has effectively dictated that everything under the balance reserves category within the defined cut-off parameter conditions should be extracted from the ground. Unfortunately, this has made it difficult to communicate with the local Russian and CIS experts on the differences between resources and reserves.

For this reason, there are constant discussions between the western experts and the local Russian teams regarding the amount of reserves available from the mine sites. This can be especially important when there are huge amounts of balance reserves that could be extracted. For example, a 'reserve' classified under the Russia/CIS system may have a mine plan covering the next two hundred years, but an assessment under the JORC Code on the same resource classifies the reserve within realistically foreseeable economic projections under a business plan covering a 20 to 30 year period.

Minimising the evaluation period to 20 - 30 years can sometimes be a difficult concept for the Russian experts to grasp, and it can be a monumental task to convince the clients that their resources/reserves did not disappear; however, the reserves assessed under the international system is only for the reliable business plan period, and at the end of this period further resources will be converted into reserves.

Re-allocating resource categories

Although it is well prescribed, one of the major issues with the Russian system is its rigidity on allocating the resources from one category to another. These are usually defined at the beginning of the projects, which can go for a long time ago, and reviewed later on if any categories need upgrading once the deposit is accessed.

There are good reasons for undertaking further exploration studies to convert categories, though it involves using lengthy statistical methods and can sometimes be a relatively costly exercise to undertake. However, companies still have to implement these exploration studies in lesser (ie C_1 and C_2) category areas and prove that they have executed them before being allowed to mine these sections as part of their mine licensing conditions.

Extreme caution must also be exercised when considering the old estimates. Once approved by the authorities, the reserves estimates may remain in the State balance indefinitely until they are updated or replaced by new estimates. This is especially important as such approval may be based on cut-off grades and other controlling parameters deemed no longer to be appropriate due to changes in technical conditions.

In addition, as the system is based on the scrutiny and approval of an independent organisation (GKZ/TKZ), the certain complexity of the procedures in preparing and defending the conditions at the various committees and the re-approval procedure at GKZ/TKZ may take a considerable length of time. This is also applicable to the old deposits, which means that bringing these historical resources up to date with current conditions – including preparing documentation and the additional compulsory geological and mining work – may take between six to 12 months or even longer. The approval procedure at GKZ/TKZ used to be very lengthy too but this has now been limited to three months (though it can be extended up to five months if further documentation is required). In a number of cases, however, the licence owner

may prefer to carry out mining according to conditions defined many decades ago, and not satisfy the current economic conditions to avoid the bureaucratic procedures that could involve additional exploration and technical work as well as additional time for approval processes.

Trust in assessments conducted by State organisations

The Russian system had a mechanism that controlled every aspect of the geological investigations and mining activity. There were many committees that checked and re-checked the results and controlled the decision-making. Anecdotal evidence indicates that the mistakes were punished by sending the technical personnel into exile, so there is a significant amount of confidence in the quality of past studies undertaken in the Soviet times.

Although the Russian system was indeed robust, there were occasions when errors were certainly made. This is especially true towards the mid-eighties when the Soviet Union was in need of financing and on the brink of collapse. The quality of work around this time deteriorated due to a lack of money and morale, which was consequently reflected in the results.

IMC's experience is that clients accept many of the results from these past investigations without questioning their validity or undertaking any further tests or studies to confirm the findings. This is especially true if the base data is no longer traceable or found anywhere, despite the geological trusts being the custodian of the original data. Therefore, IMC always checks the data to ensure that the fundamentals of the reserve estimations are in place.

Selecting cut-off parameters through the State approval procedure

As a rule, a TEO of conditions reviews different systems of mining subsurface areas and mining boundaries with a view to justifying the optimum solutions. A TEO of conditions normally reviews several options of a set of minimum parameters (conditions). Each of the options is accompanied by a corresponding technical and economic evaluation and assessment of 'potential' balance reserves.

As a rule, GKZ approves an option of conditions that is characterised by a maximum reserve tonnage while mining being still profitable. The State, as a subsurface owner, is interested not only in royalties, tax charges and the creation of new jobs in the project area, but in maximising the utilisation of processing and machine-tool industries and transport companies. In some cases, this results in minimising the economic indicators related directly to the mining of the deposit, and mining at the minimum acceptable level from the investor's point of view. Macroeconomic effect due to the deposit development also needs to be illustrated by the so-called State Budget efficiency – an indicator of economic impact at the regional and state level included in the TEO of conditions and also dictated by law.

If there are high reserve tonnages in place, the subsurface user is interested in maximising profit by focusing on areas requiring smaller investment and characterised by higher profitability. This often results initially in eliminating areas with the most complicated geological structure and mining conditions. In a number of cases, it brings about loss of these resource tonnages. Thus, preparation of technical and economic evaluation made in the framework of 'ground conditions' may consider different options; for example, a set of minimum coal seam thickness accepted for estimates: 1 m, 1.5 m, 2 m, etc. Even if the total project efficiency (internal rate of return, net present value) turns out to be higher with 2 m seam thickness, an option with thinner seam thickness that is characterised by higher reserve tonnage may be approved by the state authority, subject to the condition that the mine is still profitable with this seam thickness selected.

Yearly reconciliation of reserves through the State approval procedure

The movement of resources and reserves in mine operations are still controlled by state authorities, effectively making the whole procedure an inventory system allowing the State to know how much of a specific mineral is present and how much tax and royalties are applicable to these reserves. Mine inspectors appointed by the State can visit the operations at regular intervals and in some cases even reside at the mine site and work alongside the local mine teams. Their role is to ensure that the operation is safely conducted according to the accepted rules and regulations, and that the amount of reserves extracted from the ground is undertaken according to prescribed mine design plans. They also check the final production figures to reconcile the remaining reserves left in the ground. The statement of the reserves prepared from the mine is approved annually by the state authorities in an official form called 5GR. This final figure will be the base for payments to the State such as royalties, taxes and fees. State involvement makes the Competent Person more confident that the movement of the reserves are checked and approved by the third parties independently.

Suitability of selected mine methodology and equipment

The TEO of conditions contains comprehensive substantiation of rational deposit access and mining method and systems, annual production and life of mine, planned quality of produced minerals, and mechanisation of mining operations as well as other design solutions. This ensures the ultimate and complete economic recovery of reserves.

The typical mining options including open pit mining, underground mining or combined system have to be assessed when choosing a mining method.

Choosing the mining system and its key elements – mineral access methodology and location of the main openings, optimum open pit envelope including slope angles and other parameters – is made on the basis of the geological and mining conditions of the deposit. As a rule, choosing the optimum deposit operating scheme involves assessing several options before selecting the best one.

Long-term mine planning and life-of-mine

Production schedules are normally developed on a year-by-year basis for the first 20 years of mining, and in further stages in some cases.

Cash flow of the mine is projected for the period (estimation horizon) of life of the reserve (but normally not more than 20 years) or the term of the licence.

Estimating the mine's optimum annual production considers the dependence of capital investment and operating expenditures on life-of-mine (LOM). For example, estimating

reserve tonnages for various (economic) cut-off grades is made by assessing several options. Firstly, one or two reserve options are accepted as the base and then estimates of their capital investment are assessed. After this, a detailed analysis follows demonstrating how changes in reserve tonnages (and correspondingly potential annual production of the mine) and the LOM influence the capital investment amount.

Economic parameters

Economic justification of the estimates used in defining the parameters of the conditions and estimating the economic efficiency of the project implementation are deliverables of all geological exploration, processing and environmental studies carried out at the deposit.

In general, standard tools are used for economic valuation: modelling of product, resource and cash flows within the estimation period (planning horizon); defining the economic effect by comparing expected total results and costs; analysing mineral market development trends; and considering uncertainties and risks related to the project implementation.

The main economic parameters used in the deposit valuation and determination of its reserve balance status are standard; these are the same ones used in international best practice and include cash flow (CF), net present value (NPV), profitability index (PI) and internal rate of return (IRR). There is one exception – the state budget efficiency that is 'NPV of the state', where the overall contribution to the state and local economy is assessed with this additional investment.

Technical and economic justification of the conditions is based on considering economic parameters, with cost estimates including all real taxes, payment and collection applicable in conforming to the current federal and local laws and conditions of the licence agreement.

The amount of capital investment is to an extent estimated by direct calculation. Operating expenditures are estimated using norms based on technological solutions of the TEO or by cost items or elements. The project's economic valuation is usually carried out at different discount rate options ranging from zero to 15 per cent.

Vertical integration of companies and issues of transparency

As in other countries, organisations in Russia can own other enterprises in addition to mines such as coke and steel plants. These chemical industries may then be vertically integrated into the entire structure, which can sometimes pose challenges since the relationship between these organisations is not easily explained economically. Some of the benefits, however, include lower transaction costs, synchronisation of supply and demand along the chain of products, lower uncertainty and higher investment, ability to secure the supply of raw material and monopolise/manipulate the market throughout the chain. Yet, there could still be problems such as higher coordination costs and greater monetary and organisational costs of switching to other suppliers/buyers. Another issue is the weaker motivation for good performance at the start of the supply chain since sales are guaranteed and poor quality may affect other inputs at later manufacturing stages.

In other cases, the company structure may be designed in such a way that the parent company is registered outside Russia or the CIS. If the production units report to these departments outside the country, it makes data accessibility difficult for the Competent Person.

IMC's experience with such situations is a mixture of cooperation and resistance within the company due to some commercial sensitivity involved; however, in many cases the information is generally provided in a transparent manner to at least satisfy the Competent Person's audit requirements.

Parallel reporting for resource and reserve statements

For a number of reasons, reporting procedures that comply with the Russian resource and reserve classification system are not currently recognised by international financial institutions. Therefore, Russian producers often resort to preparing a parallel statement of resources and reserves to be consistent with one of the international standards, usually JORC. This is done using independent international mining consultancy organisations, such as IMC, to establish greater confidence in the estimations.

Consistency with international standards may be influenced or necessitated by:

- attracting a foreign investor
- obtaining a credit facility
- an initial public offering (IPO) procedure and/or uplifting the company to an international level
- changing owners
- an internal audit and keeping pace with the international financial reporting practice.

Parallel reporting does not remove the necessity of complying with the Russian system of classification due to the well-grounded objections raised by main advocates of the current system; that is, Russian geologists and specialists who face the monumental task of reconciling both local and international systems nationally.

The JORC Code is one of the most popular reporting systems in Russia and is used by most of the major mining companies where dual reporting is employed. It should be noted that in 2013, Russian President Vladimir Putin set forward the initiative to make preparation of reserve and resource estimates under international standards easier and more transparent, especially in the area of revealing the secrecy on GIS.

To achieve the task of reporting Mineral Resources so that they are consistent with the requirements of international financial institutions, the subsurface user may consider two main approaches:

1. Independent reworking of the original geological information containing *Mineral Resource* estimates so that they are consistent with the JORC Code or other international standards. This is followed by *Ore Reserve* estimates in the course of technical and economic evaluation (at least at the Pre-Feasibility Study level) with a Competent Person in charge of reserve estimates considering all specifics of the Russian legal environment. All mining losses and other mining indicators shall be accordingly adopted while considering the legal and regulatory bases in force.
2. Reclassification (conversion) of the available data on estimating the 'balance reserves' under the Russian system of classification into resources and reserves under the JORC Code or other international standards. This is

with the experts' verification of the available results of geological studies and technical and economic evaluations that comply with the Russian standards.

It should be noted that converting 'balance reserves' into international categories of resources and reserves is not a straightforward process, requiring a Competent Person's input and verification. This can sometimes be a daunting task, especially when the available TEO of cut-off parameters and Russian project studies are more complicated than typical. In such circumstances, the direct conversion of industrial reserves into international reserve categories may not always be possible. In a number of cases, conditions that the balance reserve estimates were based on are out of date and may therefore require additional studies. Furthermore, market dynamics, actual conditions of the company's fixed assets and the status of mining operations may require new analysis of all the factors influencing technical feasibility and economic viability of the deposit mining. This necessitates quite a complex technical and economic analysis and involvement of a wide range of specialists qualified both in mining, geology and economics, law, environment, processing and other fields.

It should be stressed that in recent years there has been a significant growth in interest to public offerings at stock exchanges by Russian mining companies, particularly in London, New York, Hong Kong and Toronto.

The London Stock Exchange especially enjoys the highest popularity among the Russian issuers by utilising the JORC Code with the assistance of IMC and other international consultants. A number of companies prefer starting preparation well ahead of their IPO with independent resource and reserve audits some years before the offering. Early resource and reserve estimation that is consistent with international standards identifies a potential lack of compliance with a company's financial reporting and technical and economic documentation that, when rectified, ensures the company is listed in a more favourable light.

IMC has prepared about 25 mineral expert reports since the company started its operation in Russia. The experience of IMC demonstrates a significant growth of assignments in Russia including reporting of resources and reserves in observance of international standards.

CONCLUSIONS

Recent demand for raw material from both the major and developing economies around the world has helped put Russia back on the map regarding the development of its vast Mineral Resources and the supply to market. This has resulted in renewed interest from both the investor and mining community to develop these commodities in an efficient manner.

It is important to remember that the current legislation in Russia (and similarly in other former Soviet Union countries) dictates that the reserves and resources must be evaluated in a well-prescribed system. Here the underlying principles for resource assessment can be fundamentally different compared to internationally accepted codes such as JORC. This is the legacy of the Soviet Union where resources were seen as national commodities that belonged to the people of the country. Therefore, it is important for western companies to understand how the Russian resource system operates and what the similarities and differences are between it and internationally accepted codes.

Although there are many strict rules and controls in place to ensure that resources have been recovered in the most efficient way for the benefit of the nation, the Russian system has become an important element in reconciling resources according to the criteria defined in internationally recognised reporting codes. The Russian system is a useful tool that offers clear guidance to Competent Persons and practitioners in a methodical way when they are assessing Mineral Resources in Russia, and should be seen as a practical complementary instrument.

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