

ICS 73.020
D 10

GB

National Standard of
the People' s Republic of China

GB/T 13908-2020
Replace GB/T 13908-2002

General requirements for mineral
exploration

固体矿产地质勘查规范总则

(English Translation)

Issue date: 2020-04-28

Implementation date: 2020-05-01

Issued by: General Administration of Quality Supervision, Inspection and
Quarantine of the People' s Republic of China
Standardization Administration of the People' s Republic of China

Contents

Foreword	III
1 Scope	1
2 Normative references	1
3 Basic principles	1
4 Purposes and stages of mineral exploration	1
4.1 Purposes of mineral exploration	1
4.2 Stages of mineral exploration	2
5 Exploration research contents	3
5.1 Metallogenic geological conditions	3
5.2 Orebody characteristics	4
5.3 Ore characteristics	4
5.4 Technical property of ore processing beneficiation, and metallurgy	4
5.5 Mining technical conditions	5
6 Level of exploration	7
6.1 Basic requirements for exploration control	7
6.2 Requirements for general exploration	11
6.3 Requirements for detailed exploration	13
6.4 Requirements for advanced exploration	14
6.5 Exploration level requirements of complex and small scale deposits for mine construction design	15
7 The requirements for green exploration	16
7.1 General requirements	16
7.2 Exploration design	16
7.3 Exploration activities	17
7.4 Environmental rehabilitation, governance, check and acceptance	17
8 Content and quality of exploration	17
8.1 Survey	17
8.2 Geological mapping	18
8.3 Hydrogeology, engineering geology and environmental geology	18
8.4 Geophysical and geochemical surveys	18
8.5 Exploration engineering	19

8.6 Sampling, sample preparation and identification for rock and mineral identification..	20
8.7 Collection, preparation and assay for chemical assay sample.....	21
8.8 Collection and test of ore processing and metallurgy technical performance samples...	25
8.9 Collection and test of rock (ore) physical and technical properties test samples....	26
8.10 Raw data preservation, logging, recording and report preparation....	27
9 Feasibility assessment.....	27
9.1 General requirements.....	27
9.2 Scoping study.....	28
9.3 Pre-feasibility study.....	28
9.4 Feasibility study.....	28
10 Classifications of mineral resources and mineral reserves.....	29
10.1 Mineral resources.....	29
10.2 Mineral reserves.....	30
10.3 Classification modifying of mineral resources and mineral reserves..	31
11 Estimation of mineral resources and mineral reserves.....	31
11.1 Technical parameters and variables for ore deposit.....	31
11.2 Basic requirements of mineral resources estimation.....	31
11.3 Basic requirements of mineral reserves estimation.....	34
11.4 Category identification of mineral resources and mineral reserves...	34
11.5 Estimation results of mineral resources and mineral reserves.....	34
Annex A (Informative) Reference Requirements for the Proportions of Mineral Resources Estimate at Each Stage of Exploration for Metallic and Non-Metallic Deposits.....	36
Annex B (Informative) Classifications of Mineral Resources and Mineral Reserves and Their Conversion Relationships.....	37
Bibliography.....	38

Foreword

SAC/TC 93 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with the rules given in the GB/T 1.1–2009. This standard replaces the GB/T 13908–2002 *General requirements for mineral exploration* in whole. The following technical deviations have been made with respect to the GB/T 13908–2002 (the previous edition).

- The sequence of chapters and items was adjusted;
- The basic principles for exploration were added (see Clause 3);
- The stage of reconnaissance was canceled, and the connotation of each stage of exploration were modified in accordance with the GB/T 17766 (see Clause 4, or 2002, 4.3);
- The exploration research level and control level were combined into exploration stage (see Clause 6, or 2002, 4.1, 4.2);
- “Reasonably determining the exploration engineering spacing and deploy the exploration” and “effectively verify the continuity of the orebody” was supplemented as purpose to determine the exploration type (see 6.1.1.1);
- The standards for the main orebody determination (see 6.1.1.2), conditions for determination of the exploration type (see 6.1.1.3) and requirements (see 6.1.1.5), and “the principle of three exploration lines” (see 6.1.1.6) for determination of the exploration type were added;
- The connotation of basic exploration engineering spacing was added (see 6.1.2.1);
- The exploration depth (see 6.1.4) and requirements for the degree of comprehensive exploration and comprehensive evaluation (see 6.1.5.2) were added;
- The requirements for the test and research on ore processing and metallurgical properties were revised (see 5.4, 6.2.5, 6.3.4, 6.4.4, 8.8, or 2002, 4.1.4);
- The principles for the determination of proportion of mineral resources, and the reference requirements for the proportions of mineral resources defined in each exploration stage of the metallic and nonmetallic deposits were added (see 6.3.6, 6.4.6 and Annex A);
- The exploration stage requirements of complex and small scale deposits for mine construction design were added (see 6.5);
- The requirements for green exploration were added (see Clause 7);
- The requirements for the conditional use of air reverse circulation drilling technology were added (see 8.5.3.5);
- The requirements for rock and mineral identification sampling, sample preparation and identification (see 8.6) and the analysis of harmful components of rocks (see 8.7.2.8) were added;
- The spectral total analysis was revised to qualitative and semi-quantitative total analysis (see 8.7.2.1, or 2002, 4.4.6);

- The requirements for chemical analysis, internal check, and external check (see 8.7.1, 8.7.2) and requirements for analytical quality check (see 8.7.4) were supplemented;
- The requirements for raw data preservation were added (see 8.10);
- The requirements for feasibility assessment were revised (see Clause 9, or 2002, Clause 5);
- The requirements of specific condition for the classification of mineral resources were added (see Clause 10);
- The requirements for the use of computer application technology (see 11.2.2), the extrapolation principle of the orebody (see 11.2.6), the measured resources and indicated resources delineation (see 11.2.7), and capping (see 11.2.8) and multi-mineral orebody delineation were added (see 11.2.10);
- The basic requirements for mineral reserves estimation were added (see 11.2);
- The Annex A in the edition 2002 was modified, and the “Classification of Mineral Resources/ Mineral Reserves” was revised to “Classifications of Mineral Resources and Mineral Reserves and the Conversion Relationships” (see Annex B, or 2002, Annex A); The Annex B and Annex C in edition 2002 were deleted, while the “Mineral Resources Estimated in Each Exploration Stage of the Metallic and Nonmetallic Deposits and the Reference Requirements for the Proportions” was added (see Annex A, or 2002, Annex B and Annex C);

This standard was proposed by the Ministry of Natural Resources of the People's Republic of China.

This standard was prepared by SAC/TC 93 (National Technical Committee 93 on Land and Resources of Standardization Administration of China).

The previous edition of this standard is as follow:

- GB/T 13908 - 2002

General requirements for mineral exploration

1 Scope

This standard specifies requirements for solid mineral exploration (hereinafter referred to as exploration), including the basic principles, purposes and stages, research contents, exploration level, green exploration, work content and quality, feasibility assessment, classifications for mineral resources and mineral reserves, as well as estimates and other aspects.

This standard is applicable to the overall deployment for all exploration stages, and is also applicable to guide the preparation of mineral type (group) exploration specifications, technical requirements, related specifications and regulations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GB/T 17766 *Classifications for mineral resources and mineral reserves*

3 Basic principles

3.1 Explore in accordance with corresponding laws and regulations, green exploration, comprehensive exploration, reasonably utilize and protect the mineral resource.

3.2 Be technically feasible, economically viable, and environmentally acceptable.

3.3 Based on the occurrence of mineral resources, exploration is carried out under the criterion of meeting the needs of varied work degrees and exploration purpose, properly balancing the means and the purpose, the local and the global, the need and the possibility.

3.4 Follow the rules of geological prospecting and proceed step by step.

3.5 Carry out exploration in parallel with relevant research, design and optimization.

4 Purposes and stages of exploration

4.1 Purposes of exploration

The purposes of exploration are to discover and evaluate mineral deposits (ore bodies) that are possible for further exploration or mining, provide relevant geological information supporting exploration or development decision, thus ultimately provide necessary geological data for mine construction design, so as to reduce investment risks in exploration and development of deposits, and obtain reasonable economic benefits.

4.2 Stages of mineral exploration

4.2.1 Division of mineral exploration stages

According to the GB/T 17766, exploration is divided into three stages: general exploration, detailed exploration and advanced exploration, which should be carried out in order of stages. When submitting the results of exploration altogether or across stages, it should also be implemented by steps with reference to the requirements of corresponding exploration stage.

4.2.2 Purposes and tasks for each stage

4.2.2.1 General exploration

The tasks for general exploration are, on the basis of regional geological survey and research, to search, check, verify and trace the mineralization clues using appropriate exploration techniques, and then discover an (mineralized) orebody. Meanwhile, through limited sampling and test work, as well as test and research, preliminarily identify the geological characteristics of the orebody(deposit) and the metallurgical properties of the ores, and have a preliminary understanding of the mining technical conditions. At this stage, it is necessary to conduct a scoping study to estimate the inferred resources, and evaluate whether it is necessary to upgrade to a detailed exploration, if thus, outline the target zones for detailed exploration.

4.2.2.2 Detailed exploration

On the basis of general exploration, the tasks of detailed exploration are, with appropriate exploration techniques and systematic sampling control and test work, as well as test and research, to identify primarily the geological characteristics of a deposit, the performance of ore processing metallurgical properties, and the mining technical conditions, which is adopted as the geological basis for planning of the property area (mine field) and advanced exploration scope identification. At this stage, it is necessary to conduct a scoping study and estimate the inferred resources and indicated resources, determine whether it is necessary to upgrade to advanced exploration, if thus, outline the target zones for advanced exploration. A pre-feasibility study and/or feasibility study may also be conducted to estimate probable mineral reserves.

4.2.2.3 Advanced exploration

On the basis of detailed exploration, the tasks for advanced exploration are, by appropriate exploration techniques, infilled sampling, and comprehensive test work, to identify in detail geological characteristics of a deposit, the performance of ore processing metallurgical properties, and the mining technical conditions, which provide necessary geological data for mine area planning with production capacity, product scheme, mining method, development scheme, ore processing and metallurgical technology, and the overall layout. At this stage, it is necessary to conduct a scoping study and estimate the inferred, indicated, and measured resources. A pre-feasibility study and/or feasibility study may also be conducted to estimate probable and proved mineral reserves.

5 Exploration research contents

5.1 Metallogenic geological conditions

5.1.1 The basic requirements for exploration research are to collect and study the results of previous regional geology and mineral research. Based on the knowledge of regional geological conditions and geological research on the exploration area, it is necessary to study continuously the metallogenic geological conditions of ore minerals, summarize the prospecting signs of known deposits and analyze the genesis of the deposits.

5.1.2 As for the conditions of the strata, it is necessary to carry out the research on the lithological characteristics (including color, composition, texture, structure, rock type, etc., the same below), thickness, orientation and distribution of the strata in the exploration area, and divide the stratigraphic sequences, lithological composites, lithofacies zone and marker layers, study the material composition, and the physical and chemical properties of rocks and lithofacies, and investigate their relationship with mineralization, consequently providing a basis for the study of ore-bearing horizons. For sedimentary minerals, the relationship between sedimentary background and mineralization should also be studied.

5.1.3 As for the conditions of the structure, it is necessary to study the geological structural characteristics of the exploration area, including the scale, shape, orientation, nature, spatial distribution range and development order of the main structures, as well as the development degree of small structures, the relationship with metallogenic zones, and the effects on ore bodies.

5.1.4 As for the conditions of the magmatic rock, it is necessary to study the scale, shape, orientation, lithological characteristics, lithofacies, geochemical characteristics, emplacement mode, intrusion stage, intrusion age, and contact relationship between rock mass and wall rock etc. for the deposits associated with magmatic intrusions; for the deposits related to volcanic activities, to study the lithological characteristics, lithofacies, geochemical characteristics of volcanic rocks related to mineralization, tectonic characteristics related to volcanic

activities, types of volcanic mechanism, eruption modes, eruption cycles, eruption rhythms, eruption ages, together with their relationship with mineralization.

5.1.5 As for the conditions of the metamorphic rock, it is necessary to study the lithological characteristics, metamorphic mineral composites, metamorphic facies and distribution characteristics of facies belts, the property, intensity, and influencing factors of metamorphism, as well as the influence of metamorphism on the formation or transformation of deposits.

5.1.6 As for the conditions of the wall rock alteration, it is necessary to study the types, mineral composition, intensity, distribution range and zoning characteristics, as well as the relationship between alteration and mineralization.

5.2 Orebody characteristics

5.2.1 To study the effect and influence of post-mineralization structures and magmatic rocks on the orebody, and find out the contrasting signs of orebody.

5.2.2 To study the quantity, scale, shape and internal texture, orientation, spatial location, thickness and variation of ore bodies, as well as contents of main useful components and associated changes, contrasting signs, continuity of ore bodies, and the overall distribution of orebody within the exploration area, etc.

5.2.3 To study the type, scale, lithology, thickness and distribution of internal waste, characteristics of non-ore area, lithology and distribution of roof and floor of ore bodies, etc.

5.2.4 To study the development degree, scope, mineral compositions and distribution of the oxidized zone, transitional zone and primary zone (referred to as "three zones") of the deposit, as well as the secondary enrichment phenomenon and enrichment rules of the deposit.

5.3 Ore characteristics

5.3.1 To study the type, content, coexisting combination of ore minerals and gangue minerals, as well as the ore texture and structure, and the embedded characteristics of the ore minerals (intergranular, fractured, interstitial, encapsulated, etc.) and so on.

5.3.2 To study the chemical composition of ores, type, content, occurrence state of useful, beneficial and harmful components (isolated minerals, isomorphism, adsorption condition, dispersion condition, etc.), as well as the change and distribution of main useful components and so on.

5.3.3 To study and classify the natural and industrial type of ores. The classes of ore shall be divided necessary.

5.3.4 For coal, to study the coal quality characteristics such as coal petrography, physical properties, chemical properties, technological performance, category and so on.

5.4 Technical property of ore processing beneficiation, and metallurgy

5.4.1 Based on the test purpose, requirements, extent and the reliability of the results in practice, ore processing and metallurgical tests are divided into five categories as amenability test, laboratory process test, laboratory expanded continuous test, pilot plant test, and industrial test; the physical and chemical property test work of non-metallic minerals is divided into three categories as preliminary test work, basic test work and detailed test work based on the research level.

5.4.2 Research on ore processing and metallurgical properties generally includes mineralogy research of ore, processing and metallurgical test work of metallic ores and some non-metallic ores, assay on physical and chemical properties of some non-metallic ores, study on processing, metallurgical ore products and tailings properties and so on.

5.4.3 Research on the ore mineralogy mainly focuses on the mineral composition, chemical composition, texture and structure, technological particle size and embedded characteristics of ore minerals, physical and chemical properties of ore, content, occurrence, distribution ratio of useful, beneficial and harmful components, and the distribution of ore, the oxidation status of the ore, etc. in the process of processing and metallurgy.

5.4.4 Test work and research on processing and metallurgical properties mainly include the amenability of ore, the availability of major useful components, the comprehensive recovery of associated useful components and the possibility of removing harmful components, the process and conditions, together with experimental indicators during ore processing and metallurgy.

5.4.5 Assay on physicochemical properties include physical and chemical property tests on some ore or non-metallic minerals, including the study of the physical and chemical properties of minerals or ores that are closely related to the technological performance of mineral products.

5.4.6 Research on processing and metallurgical refinery ore products and tailings properties is through analyzing the quality of concentrates and metallurgical products, the mineral composition, grade, particle size composition of tailings and their utilization methods or application trends, as well as sedimentation characteristics and indicators, toxic leaching, and purification as well as treatment of processing wastewater.

5.5 Mining technical conditions

5.5.1 Hydrogeological conditions

The main research contents of hydrogeological conditions are as follows:

a) Regional hydrogeological conditions, characteristics of the hydrogeological unit in which the exploration area (mine area) is located, recharge, runoff, and discharge conditions of groundwater.

- b) The lithology, thickness, orientation, distribution and burial conditions of aquifer and aquifuge, water bearing and permeability of aquifers, hydraulic connection between aquifers, the level, quantity, quality, temperature of groundwater and dynamics variation, stability and water barrier properties of aquifuge.
- c) Development degree, distribution, water bearing and conductivity of fault fracture zones, joints, weathered fracture zones and karst caves, distribution of surface water as well as the means and extent of hydraulic connection with the main aquifers of the deposit, etc.
- d) Distribution, depth, water accumulation and subsidence of goafs.
- e) The complexity of the hydrogeological conditions of the deposit.
- f) Normal and ultimate groundwater yield of mine, and rainfall catchment in open pit mines.
- g) Water supply source (direction), water quantity, water quality, etc.

5.5.2 Engineering geological conditions

The main contents of the research on engineering geological conditions are as follows:

- a) The physical and mechanical properties of the orebody and the rock on the roof and floor, such as density, hardness, moisture, lumpiness, compressive strength, shear strength, loosening coefficient, angle of repose, joint density, rock quality designation (RQD) value, etc.
- b) The influence of structure, weathered zone, weak interlayer, etc. on the mining of the deposit.
- c) The lithology, thickness and distribution of Quaternary strata.
- d) Slope stability of the open pit.
- e) The complexity and the type of engineering geological conditions of the deposit.
- f) The main engineering geological problems that may arise during the mining of the deposit.

5.5.3 Environmental geological conditions

The main research contents of environmental geological conditions are as follows:

- a) Relevant environmental geological phenomena (rockslides, landslides, debris flows, land subsidence, ground fissures, karst, ground temperature, etc.), the quality of surface water and groundwater, the content and distribution of radioactive elements and other harmful substances in the exploration area (mine area).
- b) Seismic geological conditions such as earthquakes and neotectonics' activities and the stability of the mine area.
- c) The quality of the geological environment before the mining of the deposit, and the possible damage together with impact on the environment and ecology of the mining area during and after the mining of the deposit.

d) For coal, the coalbed gas, ground temperature, ground pressure, spontaneous combustion potential, and coal dust explosion, etc. should be studied as well.

6 Level of exploration

6.1 Basic requirements for exploration control

6.1.1 Exploration types

6.1.1.1 The exploration types shall be reasonably determined for precisely selection of the exploration method and techniques, reasonably determine the exploration engineering spacing and effectively control the deposit, and verify the continuity of the orebody as well.

6.1.1.2 The exploration types shall be determined according to the characteristics of the main orebody, namely, one or more ore bodies that will be the main mining targets. At the exploration stage, the main ore bodies are generally determined according to the scale of the mineral resources of the ore bodies, and the mineral resources (generally the main minerals, if necessary, the paragenetic commercial minerals shall also be considered) of one or more ore bodies which occupy over 60% of the total mineral resources of the deposit shall be selected as the main ore bodies (listed from bigger to smaller in mineral resources), which is specified in the specifications for different types of minerals (groups) in the light of their own characteristics.

At the general exploration stage, it is difficult to determine the exploration type since the basic characteristics of the ore body are not identified. However, if comparable, the exploration type can be preliminarily determined by comparison with the similar deposits. At the detailed exploration stage, the exploration type shall be determined according to the related main geological factors. At the advanced exploration stage, the exploration type shall be verified in the light of changes in the main geological factors affecting the exploration type, and the exploration type shall be adjusted if it is verified to be unreasonable.

The exploration types are generally classified into three types as simple (type I), medium (type II), and complex (type III) according to the scale of the orebody, the shape and complexity of the internal texture, the degree of thickness stability, the division of distribution uniformity of the useful components, and the complexity of the structure, together with other major geological factors. In view of the complexity of geological factors, transitional exploration types such as simple-medium type (type I-II) and medium-complex type (type II-III) also could be defined. The specification for different mineral type (group) shall, in accordance with the characteristics of the different mineral type (groups), reasonably determine the main geological factors affecting the division of the type of exploration, as well as reasonably divide the type of exploration and determine the conditions of different type

6.1.1.3 At the general exploration stage, it is difficult to determine the exploration type since the basic characteristics of the ore are not identified. However, if comparable, the exploration type can be preliminarily determined by comparison with the similar deposits. At the detailed exploration stage, the exploration type shall be determined according to the related main geological factors. At the advanced exploration stage, the exploration type shall be verified in the light of changes in the main geological factors affecting the exploration type, and the exploration type shall be adjusted if it is verified to be unreasonable.

6.1.1.4 When determining the exploration type of deposit, the overall scale of the orebody shall be considered, the exploration type of each orebody shall be determined according to the geological characteristics, and exploration type of deposit shall be determined according to the characteristics and spatial relationship of the main ore bodies. When exploration type of the main ore bodies varies, the characteristics of the main ore bodies and the requirements of the research level of the overall control factors of the deposits should be comprehensively considered, and the exploration types of the deposits shall be reasonably defined. For large-scale deposits (orebody) with significant differences related to the exploration difficulty of different sections, the exploration type can be defined by sections (or portions).

6.1.1.5 In principle, when a certain orebody is defined to be a certain exploration type (except Type III), it shall be possible to be continuously controlled by minimum three exploration lines at the basic exploration engineering spacing of the corresponding exploration type, and orebody shall be intersected in no less than two consecutive engineering works per line.

6.1.2 exploration engineering spacing

6.1.2.1 The exploration engineering spacing should be reasonably determined according to the exploration types. For deposits of different types of minerals and different exploration types, the exploration engineering spacing for delineation of indicated resources is defined as the basic exploration engineering spacing. The reference values are specified by the specifications of different mineral type (group).

6.1.2.2 Generally, the exploration engineering spacing of measured resources is narrowed down 50% against the basic exploration engineering spacing and that of inferred resources is two times of the basic exploration engineering spacing, but not limit as these, to meet the requirements of the corresponding exploration research degree. During practical exploration process, methods such as comparison, geostatistical analysis, engineering verification, etc. shall be applied for the detailed exploration and advanced exploration stages to demonstrate the rationality of the exploration engineering spacing, and shall be adjusted as needed.

6.1.2.3 When the variations of orebody along the strike or dip are inconsistent, the exploration engineering spacing should be adapted to the variations. When the orebody is exposed to the surface, the spacing of surface exploration should be appropriately increased, so as to further study the metallogenic regularity and ore-control regularity, as guidance for deep exploration.

6.1.3 Exploration planning

6.1.3.1 On the basis of reasonably determining the exploration type and exploration engineering spacing, considering the geological characteristics of the orebody and the needs of mine construction, the conditions of topography, geophysical survey, and geochemical survey, and requirements for ecological and environmental protection, exploration methods and techniques which are appropriate, effective, and have less impact on the ecological environment shall be selected. Meanwhile, the exploration shall be deployed according to the exploration type and the corresponding exploration engineering spacing, controlling the deposit in general. It is necessary to adjust local exploration engineering spacing by specific conditions, so as to strengthen the understanding of local ore bodies (such as areas of great variety in ore bodies) and secondary ore bodies.

6.1.3.2 In general, trenching, soil stripping, shallow shaft, surface boring, small round shafting and other green and effective alternative exploration methods are mainly adopted on the surface, supplemented by shallow-hole drilling, combined with effective geophysical and geochemical surveys. And core drilling is mostly conducted in depth. When the shape of the orebody is complex, in the shape of a tube, and the composition of the ore material varies greatly, resulting in difficulty to achieve the exploration purpose by drilling, tunneling should be adopted as the main method supported by drilling, or through tunneling for verification. When the geological results obtained are similar to the results of tunneling verification, further tunneling are not required. When the terrain is favorable, tunneling shall be primarily considered. When it is necessary to collect bulk samples of mineral processing, tunneling can also be adopted. During the exploration, general operations such as geological mapping, geophysical survey, geochemical survey, remote sensing, and heavy-mineral survey should be carried out first, in order to guide and optimize the layout and construction of exploration work.

6.1.3.3 In general, limited sampling is carried out for study in general exploration stage, and systematic sampling control (according to a certain and regular exploration engineering spacing) is carried out in detailed exploration stage. The sampling density in advanced exploration stage is reasonably increased on the basis of detailed exploration.

6.1.3.4 During the exploration, attention should be paid to study the overall distribution range and mutual relationship of ore bodies within the exploration scope. As for the boundary of the outcropped orebody, the orientation and scale of the larger undulating basement, non-ore area, structure, vein, karst, salt solution,

mud ridge, mud column, collapse column and goaf that damage the orebody and affect extraction, as well as boundary of the mining area (mine field), there should be engineering controls. The small orebody that can be mined simultaneously with the main orebody should be properly controlled. For the ore deposit to be mined underground, the main orebody should be controlled specially at the two ends, the upper and lower boundaries and the extension of the ore deposit. For the open pit mine, the boundary around the orebody and the boundary of the orebody at the bottom of the pit should be systematically controlled. For the main blind orebody, the top boundary should be controlled.

6.1.4 Exploration depth

6.1.4.1 The exploration depth should be determined scientifically and reasonably. When there is certain mineralization potential at depth, the common practice for exploration shall be carried out to the depths of the corresponding minerals generally required. The exploration depth shall be increased properly if the internal and external conditions of deposit are favorable, or in the edge or deep part of mine with long history, while the specific requirements shall be stipulated by the mineral type (group) according to the actual mining conditions.

6.1.4.2 Comparison is recommended to determine the exploration depth if conditions permit, otherwise, the exploration depth shall be determined through demonstration. Study on mining technical conditions shall be strengthened properly for the deep orebody exploration.

6.1.5 Comprehensive exploration and comprehensive evaluation

6.1.5.1 The comprehensive exploration and comprehensive evaluation for the deposit shall be carried out at each stage of exploration. The specific requirements shall be implemented in accordance with the relevant specifications of the comprehensive exploration and comprehensive evaluation and the different ore mineral type (group).

6.1.5.2 At the stages of detailed exploration and advanced exploration, the multi-mineral orebody or paragenetic commercial minerals in different orebody with a resource scale of medium or above shall be overall considered together with the main minerals, and the evaluation shall be conducted according to the requirements for the corresponding paragenetic commercial minerals exploration. As for the exploration level, the detailed exploration is generally required to reach the stipulated corresponding requirements by exploration specifications, and the degree of advanced exploration shall depend on the specific situations. For the paragenetic commercial minerals with a small-scale mineral resources, the infill control shall be carried out depending on the situation and requirements of the engineering that control the main minerals, and the evaluation shall be carried out according to the requirements for the corresponding paragenetic commercial minerals exploration.

6.1.5.3 Associated minerals are usually controlled by the engineering that controls the main minerals. A comprehensive recovery plan shall be studied and proposed for the associated minerals which have reached the comprehensive evaluation reference index and can be recycled under the current technical and economic conditions. For the associated minerals that do not meet the comprehensive evaluation reference index or are not included in the comprehensive evaluation reference index, but can be produced separately in the ore processing and metallurgy, or can be enriched in a product to meet the valuation standard, research should be carried out to propose comprehensive recycling and utilization pathways, and evaluation should be carried out accordingly.

6.1.6 Radioactive inspection

Radioactive inspection should be conducted on the radiative minerals at all the stages of exploration in accordance with the general requirements for exploration, and strengthen the evaluation of the radioactive impact on human health and environment. Radioactive inspection shall be carried out for non-radioactive minerals exploration and the samples shall be collected and tested as required when the assay results report anomaly values. Further work shall not be conducted if the radionuclide content in orebody or wall rock exceeds an allowable limited value and cannot be recovered, meanwhile the human health and environmental protection may be affected and there are no effective prevention and treatment measures.

6.1.7 Data collection and utilization

Regional geological data should be comprehensively collected at each stage of exploration, particularly for the geology, minerals, geophysical and geochemical surveys, remote sensing, heavy mineral survey, exploration engineering, sampling test, test and research data, and the latest research results in and around the exploration area. All the data are fully studied and utilized.

6.2 Requirements for general exploration

6.2.1 On the basis of fundamental geological research, by carrying out geological mapping (generally a simple geological survey map), remote sensing interpretation and outcrops inspection in the exploration area at a scale ranged from 1:25,000 to 1:5,000, and combined with exploration engineering, it is necessary to study mineralized geological rules, compare to known deposits, discuss the genesis of mineral deposit, summarize the mineralization markers and preliminarily identify the metallogenic geological conditions as well as the characteristics of the mineralized bodies in the exploration area. For sedimentary minerals such as coal, detailed classification of coal bearing strata should be carried out, with focus on the research of sedimentary environment and facies, metallogenic regularity and ore-control regularity, and preliminarily identifying the structure.

6.2.2 The mineralization anomalies shall be verified, checked, traced and evaluated one by one through the ore (mineral) occurrence inspection, 1:10,000 or larger scale geophysical and geochemical surveys profile measurement (or a comprehensive profile of geology, geophysical and geochemical surveys) or area measurement, and necessary sampling, etc.

6.2.3 The discovered orebody, especially the major ones, shall be controlled by sparse sampling on the surface, especially for the main orebodies, with the deep verification by engineering, while systematic engineering control is not required, however, the reasonable connection with the subsequent exploration engineering layout should be considered as much as possible. Geological mapping (simple or normal geological survey map) shall be carried for the deposit outcropped on the surface as required at a scale ranged from 1:5,000 to 1:1,000. The continuity of the orebody is reasonably interpreted through research on the control, to preliminarily identify the geological characteristics of the main orebody and the overall distribution in the exploration area.

6.2.4 By means of mineral identification (identification of rock and mineral, the same below), testing, analyzing and comparing to a known deposit with a similar geological characteristic by sparse sampling engineering, it is necessary to preliminarily identify the ore features such as material composition, texture and structure, embedded characteristics of ore minerals, contents and occurrence of useful, beneficial and harmful components, as well as the natural types of ore, etc.

6.2.5 On the basis of the ore processing mineralogy and mineral processing technology, the comparative research on the easy processing ore should be carried out. Generally, comparative research on the medium difficult processing ore is carried out, and the amenability test shall be carried out if necessary. For the new types of ore and difficult processing ore, the amenability test is generally adopted, and the laboratory process test shall be conducted if necessary. The preliminary testing research on physical and chemical properties for some non-metallic minerals is carried out, and the basically testing research shall be carried out if necessary. The technical performance of ore processing and metallurgy in the exploration area is preliminarily investigated.

6.2.6 The information related to the hydrogeology, engineering geological and environmental geology of the region and the exploration area shall be collected and investigated by comparison with mines which have similar mining technical conditions. For deposits with highly complex mining technical conditions, the hydrogeological and engineering geological work shall be assigned properly to preliminarily investigate the hydrogeological, engineering geological, environment geological conditions of the exploration area. The types of hydrogeological and geological engineering exploration are preliminarily classified.

6.2.7 When one orebody is discovered, and under the premise of complying with geological rules, the inferred resources can be estimated according to the

exploration type preliminarily determined or Type II (in case with no such analogy conditions) and the corresponding exploration engineering spacing.

6.3 Requirements for detailed exploration

6.3.1 On the basis of general exploration, the metallogenic geological conditions and the characteristics of mineralized orebodies in the exploration area are basically identified through the geological mapping prepared for the mining area at scale of 1:25,000 – 1:5,000 (normal geological survey map) and geological mapping for the deposit at scale of 1:5,000 – 1:500 (normal geological survey map), combined with engineering control and exposure, to elucidate the geological conditions, characteristics, metallogenesis and metallogenic regularity of a deposit.

6.3.2 Once the exploration type is determined, through using reasonable exploration engineering spacing, effective exploration techniques and methods, and systematic sampling engineering, the deposit is controlled. The characteristics of ore bodies are basically ascertained. The work is to primarily identify the number of main ore bodies, basically control the scale, shape, orientation, spatial location and the overall distribution of ore bodies in the exploration area, and basically determine the continuity of the main orebodies. Further work should be done on the structures affecting the mining area (field) division, as well as large structures and magmatic rocks that control, damage and affect the orebody.

6.3.3 Sampling, testing and analyzing in systematic engineering works are conducted to basically identify the ore features such as material composition, texture and structure, ore particle size and embedded characteristics of ore minerals, content of useful, beneficial and harmful components, occurrence and variation, nature and industrial types, etc.

6.3.4 On the basis of ore mineralogical research and mineral processing technology, the comparative research and amenability test are carried out for easy processing ore depending on the circumstances, and laboratory process test shall be conducted if necessary. The amenability test and laboratory process test are carried out for the medium difficult processing ore according to the circumstances. The laboratory process test is carried out for new types of ore and difficult processing ore, and laboratory expanded continuous test shall be conducted if necessary. The preliminary testing research on physical and chemical properties for some non-metallic minerals is carried out, and the detailed testing research shall be carried out if necessary. The technical performance of ore processing and metallurgy in exploration area is basically identified.

6.3.5 Investigation of hydrogeology, engineering geology and environmental geology shall be carried out for the area that may be affected by the mining operation (include the extent of affected mine requiring drainage, destructive area by ground deformation, waste dump and possible contaminated area). Necessary pumping and drainage experiment shall be carried out to basically identify the hydrogeological, engineering geological and environment geological conditions, and classify the

types of hydrogeological and engineering exploration. Investigate the deposit water filling factors, the engineering geological characteristics, the roof and floor of ore bodies, wall rock of the adits and shafts, stripping materials and slope engineering characteristics of open pit, etc. The major issues that affect deposit mining from the hydrogeological, engineering geological and environment geological aspects are predicted.

6.3.6 Indicated resources and inferred resources are generally estimated with reasonable proportion of distribution for the area that above the determined exploration depth. Indicated resources shall be concentrated in the section that may be mined primarily or at early stage. While for the area below the determined exploration depth, further work is usually not required, but evaluation on the metallogenic prospect shall be carried out. The proportion of mineral resources for metal and non-metallic mineral deposits at the detailed exploration stage can be referred to the requirements of Annex A. The mineral resources proportion in line with the actual ore mineral type is determined for each type of ore minerals (group) according to the related characteristics, and the corresponding regulation shall be implemented.

6.4 Requirements for advanced exploration

6.4.1 On the basis of detailed exploration, it is necessary to revise the geological map of the exploration area and the geological map of the mine (should be prepared as normal geological survey map) as needed or carry out a large-scale geological mapping (normal geological survey map), combining with the engineering of infill control and exposure. The metallogenic geological conditions and characteristics of mineralized geological bodies, the mineralization and metallogenic genesis and regularity should be identified in detail.

6.4.2 On the basis of systematic engineering control of detailed exploration, the necessary infill drilling shall be carried out through effective exploration methods to control the orebody as well as the large structures and magmatic rocks which may control, damage and affect the orebody. The mineral characteristics of the main orebody such as scale, shape, orientation, spatial location, continuity and the overall distribution are identified in detail.

6.4.3 On the basis of infill engineering and through sampling, testing and assaying, it is necessary to identify the characteristics of ore such as material composition, texture and structure, ore particle size and embedded characteristics of the mineral, as well as the types of useful, beneficial and harmful components, occurrence and content of useful components and the variation, ore nature and industrial types, so as to meet the basic requirements of mine construction design in terms of characteristics research on the ore quality.

6.4.4 On the basis of detailed study on ore processing and mineralogical research, for easy processing ore, laboratory process test shall be conducted; for medium difficult processing ore, laboratory process test shall be conducted, and laboratory

expanded continuous test shall be carried out if necessary. For difficult processing ore, the laboratory process test and laboratory expanded continuous test are conducted, and pilot plant test and industrial test shall be conducted if necessary. A detailed testing research on physical and chemical performance for some non-metallic minerals shall be carried out. The technical performance of ore metallurgy and processing is preliminarily investigated to provide a reasonable ore processing and metallurgical flowsheet for the mine construction and design.

6.4.5 The hydrogeological conditions of the exploration area and water filling factors of the deposit shall be investigated in detail. The calculating parameters are obtained to estimate the groundwater yield of mine in the initial mining area (first mining level), and the comprehensive utilization for underground water resources is evaluated to provide suggestions for water prevention and treatment in mine, and point out the direction of water supply sources (direction). The engineering geological conditions are identified in detail to evaluate the engineering geological characteristics of orebody and the roof and floor, quality and rock mass stability of the wall rock and open pit, analyze and evaluate the main engineering geological hazards that may occur under the mining conditions, and propose suggestions for prevention and treatment. The quality of geological environment in the mining area is investigated and evaluated to predict the main environment geological issues that may be caused by the development of the deposit, proposing suggestions for prevention and treatment.

6.4.6 Measured resources, indicated resources and inferred resources are generally estimated for the area above the proposed exploration depth, and a reasonable proportion is also required. The stage of advanced exploration shall focus on the initial mining area with consideration of the whole mining area. The measured resources and indicated resources shall be fundamental within the initial mining area (early mining section for coal). While for the area below the determined exploration depth, further work is generally not required, but evaluation on the metallogenic prospect shall be carried out. Generally, according to the principle of "Ensure that principal and interest are repaid in the initial mining area, and mine construction risks are controllable", the proportion for each resource category shall be reasonably determined after demonstration. The proportion requirements of mineral resources for metallic and non-metallic mineral deposits at the advanced exploration stage can be referred to Annex A. The mineral resources proportion in line with the actual ore mineral type is determined for each type of ore minerals (group) according to the related characteristics and the corresponding regulation shall be followed.

6.5 Exploration level requirements of complex and small scale deposits for mine construction design

6.5.1 Metallic and non-metallic complex deposits refer to the deposit which is difficult to estimate the measured resources with infill sampling on basic spacing

of exploration work, or difficult to estimate the indicated resources with basic spacing of exploration work in Type III. For complex large and medium-scale deposits which are difficult to estimate the measured resources with infill sampling based on basic spacing of exploration work, the indicated resources shall be estimated, and the final detailed exploration report shall be submitted as the basis for the mine construction design. For the complex small scale deposit which is difficult to estimate the indicated resources with basic spacing of exploration work, the inferred resources shall be estimated, and the final general exploration report shall be submitted as the basis for being explored while mining during the mine production stage.

6.5.2 The level of final detailed exploration requires that the characteristics of orebody and ore quality research for exploration control of small deposit for mine construction design shall generally reach the level of detailed exploration. The level of final general exploration requires characteristics of orebody and ore quality research and control for exploration shall generally reach the level of general exploration. Moreover, the research level of exploration control on the other aspects shall meet the requirements of advanced exploration. The requirements of mineral resources proportion are referred to Annex A.

6.5.3 The geological risks should be fully considered when the final detailed exploration report and final general exploration report are used as the geological basis for the mine design, which is not suitable for the construction of large, and medium-scale mines.

7 The requirements for green exploration

7.1 General requirements

7.1.1 The requirements for green development and ecological environment protection shall be applied throughout the whole process of exploration design, construction, check and acceptance, and delivery, to minimize the impact on the environment in the whole process of exploration.

7.1.2 By relying on technology and management innovation, the disturbance, pollution, and damage to the ecological environment caused by exploration activities are maximumly avoided or reduced. The exploration technique that provides an effective alternative to trenching and costeaning is recommended, and the exploration technique with less land occupation such as “one platform with multiple drillholes, one drillhole with multiple purposes” is encouraged.

7.1.3 Environmental protection knowledge and skills training should be provided to the workers to enhance the awareness of environmental protection, and the requirements of green exploration shall be implemented effectively.

7.2 Exploration design

7.2.1 The requirements of green mineral exploration shall be fully reflected and clearly proposed in the exploration design.

7.2.2 On-site survey shall be carried out prior to the exploration design to predict the potential impact and degree on ecological environment by the exploration activities.

7.2.3 The relationship between the exploration purposes and tasks and the protection of ecological environment shall be coordinated during the process of exploration design. Appropriate exploration methods, technological means, equipment, technology and new materials shall be adopted to reasonably deploy the exploration engineering. Operational and technical arrangement for green exploration in all aspects of the exploration activities shall be deployed, such as site selection, road routing, stockpiling, waste disposal, various engineering construction, environmental rehabilitation and governance. The measures for prevention and control, as well as for the organizational management shall be proposed.

7.3 Exploration activities

7.3.1 The activities of mineral exploration shall be carried out in strict compliance with the requirements of the exploration design. The green exploration requirements shall be fully considered for the optimization of exploration design.

7.3.2 Effectively management and control shall be conducted against the damage of soil and vegetation caused by vehicles, personnel passage, and land occupation, the waste gas pollution from mechanical operation, light and noise disturbance from equipment operation, damage caused by digging and burying detectors and excitation and blasting, and collapse and slope type mudflow caused by excavation of soil and rocks, and the mud (waste water, waste residue, waste oil, etc.), domestic garbage, and waste, etc.

7.4 Environmental rehabilitation, governance, check and acceptance

7.4.1 When the exploration or stage work is completed, the environmental rehabilitation and governance work shall be carried out in time against the environmental impact of exploration activities in accordance with national laws and regulations, mandatory standard and requirements of rehabilitation and governance design to minimize the negative impact of the exploration activities on the ecological environment.

7.4.2 The implementation of green exploration requirements shall be used as important criteria for check and acceptance of the project.

8 Content and quality of exploration

8.1 Survey

8.1.1 All the geological profile and exploration involved in the resource estimation shall be surveyed. The survey accuracy shall conform to the relevant specifications.

8.1.2 A unified national coordinate system and national elevation datum shall be adopted for the survey. China Geodetic Coordinate System 2000, Gauss-Kruger projection shall be employed for planar coordinate systems, and elevation system adopts the national height datum 1985.

8.2 Geological mapping

8.2.1 Geological mapping at various scales shall be prepared according to the requirements of exploration control and research level at different exploration stages, the dimension of orebody, thickness, and the complexity of the structure. The mapping requirements shall be in accordance with the relevant specifications and standards.

8.2.2 Geological sketch map can be prepared using topographic base map or the topographic base map enlarged by small-scale topographic map with field correction. A simple geological map can be prepared by using topographic map at large or small scales. The precise topographic base map should be used in the normal geological survey map.

8.2.3 The geological mapping shall be carried out based on geological observations, and the observation points shall be on the geological boundary or the location of special significance, which shall be displayed on the map accurately. For the geological phenomena with special significance, detailed observation and records should be made when necessary.

8.2.4 Various remote sensing geological data shall be fully used to collect as much as possible the mineralized alteration information in order to improve the work efficiency and quality for geological mapping in the area with suitable conditions.

8.3 Hydrogeology, engineering geology and environmental geology

The hydrogeology, engineering geology and environmental geology survey at various scales shall be carried out to meet the work requirements of hydrogeology, engineering geology and environmental geology at corresponding exploration stage. Hydrogeological surveys, engineering geological surveys, environmental geological surveys, and specialized hydrogeological work shall be performed in accordance with the relevant specifications and standards.

8.4 Geophysical and geochemical surveys

8.4.1 According to the physiographic factors of the exploration area, and the geology, geophysics and geochemistry conditions, the comprehensive profiles of geochemistry for geology and geophysics, are surveyed by methodological experiment, and effective geophysical and geochemical surveys are selected for exploration, search, delineation and evaluation of the geophysical and geochemical anomalies,

to study and estimate the mineralization clues, interpret the structure of the exploration area, analyze the continuity of the orebody, predict the thickness of orebody and the spatial distribution, etc. Geophysical and geochemical surveys and corresponding quality requirements shall be executed in accordance with the relevant specifications and standards.

8.4.2 The geophysical and geochemical anomalies with prospecting significance shall be further inspected and evaluated by some comprehensive methods such as geological, geophysical and geochemical surveys, and exploration engineering for the mineralization clues.

8.4.3 When methods and techniques of exploration are proven to be effective, drilling and other engineering should be fully utilized for borehole geophysical logging, so as to search the blind orebody, and to study the shape, orientation, and correlation of ore bodies.

8.4.4 Encourage research on quantitative geophysical methods and their applications, which can be involved in mineral resource estimation under the premise of ensuring the geological reliability.

8.5 Exploration engineering

8.5.1 Surface exploration

Surface exploration such as trenches, soil stripping, shallow pit, shallow shaft, small circular shaft and other environmental protection and effective alternative exploration methods should be employed to expose the superficial ore bodies, orientation, and key geological boundaries, and systematically control the actual location of orebody at the surface and near surface. All surface exploration should be exposed to the bedrock, and the engineering works controlling the orebody should expose the roof and floor. Surface exploration execution and the quality requirements shall be implemented in accordance with the relevant regulations.

Drilling by portable drill rig is encouraged to serve as an alternative to trenching and costeaning in case the target can be achieved. Group drilling should be conducted if necessary. For the orebody with thick overburden or deep oxidized zone, shallow-hole drilling shall be used as an alternative when it is difficult to achieve the target by trenching, costeaning, and portable drilling, etc.

8.5.2 Tunneling

Tunneling is more effective to expose various complex geological conditions for studying the characteristics of orebody and ore quality. tunneling is conducted mainly for exploration and should also be considered for utilization in future mine construction and production. tunneling shall be combined with other exploration engineering that have been completed, arranged and proposed. tunneling and the quality requirements shall be carried out in accordance with the relevant regulations.

8.5.3 Drilling

8.5.3.1 Drilling (including underground drilling, the same below) should adhere to the principle of one borehole for multiple purposes. Drilling and the quality requirements shall be implemented in compliant with relevant regulations.

8.5.3.2 The recovery rate of the drill core, the recovery rate of the wall rocks within 3–5 m of the roof and floor of the orebody and the recovery rate of the rock (ore) core of the marker layer shall be greater than 80%. If the recovery rate for a continuous length of 5 m of core in the thick ore bodies is less than 80%, remedial measures shall be taken in time. The core recovery rate for general rock shall not be less than 80%, and the core recovery rate for the soft rock and fractured rock shall not be less than 65%.

8.5.3.3 The hole diameter of the drill core should meet the sampling requirements, and the diameter of the rock (ore) core should be able to ensure the representativeness of the sampling point. The drilling technology employed should be able to maintain the original texture characteristics and integrity of the ore, avoid crushing and dilution of the core. For multi-vein type and multi-belt type deposits, the length and the recovery rate of each drilling pass should be strictly controlled to prevent ore loss during drilling.

8.5.3.4 Measure the dip angle and azimuth angle of the boreholes as required. And conduct downhole survey, depth correction, simple hydrogeological observation, original records, borehole sealing, and core storage. If the drilling quality does not meet the requirements and has a great impact on the delineation of the orebody or the resource estimation, remediation should be conducted promptly. If the quality of the borehole sealing does not meet the requirements of the regulations or exploration design, resealing is required.

8.5.3.5 When the characteristics of the orebody and the ore are basically identified, when using air reverse circulation (RC) drilling technology and taking rock powder (chip) samples for sampling and assay can achieve the exploration purpose or be more effective, the RC drilling technology can be used for infill drilling to control the orebody. But the changes from ore to waste rock should be further studied in detail, and the sampling interval should be strictly controlled. For boreholes drilled by air reverse circulation drilling technology, the reduction can be used for sampling while ensuring sampling representativeness.

8.6 Sampling, sample preparation and identification for rock and mineral identification

Representative rock and mineral identification samples should be taken according to the orebody, mineral type and grade, and the rock type of the wall rocks near the orebody, to identify the mineral composition of rock and ore, texture and structure, and rock or ore type. The sample quantity shall meet the research needs. The sample preparation and identification of the rock thin sections and ore polished sections should be carried out in accordance with relevant standards.

8.7 Collection, preparation and assay for chemical assay sample

8.7.1 Basic requirements

8.7.1.1 The samples collected should be representative. The sampling method shall be determined based on the purpose of sampling, combined with the exploration method, the dimension and thickness of orebody, ore texture and structure, mineral particle size, etc. Sample specifications should be determined through experiments or analogies, and the sample weight shall meet the testing needs. Selective sampling is not allowed to avoid low grade ore in favor of high grade ore or avoid high grade ore in favor of low grade ore.

8.7.1.2 Chemical analysis, internal check analysis (referred as to internal check), and external control analysis (referred as to external check) shall be conducted by laboratories with metrological certification qualification. External check shall be undertaken by laboratories with national level metrological certification qualification.

8.7.2 Sample collection and analysis items

8.7.2.1 Qualitative and semi-quantitative total analysis

Qualitative and semi-quantitative analysis of the ore (rock) shall be carried out to understand the elemental (component) composition of the ore (rock) and its approximate content. If ore properties vary greatly at stages of general exploration, detailed exploration and advanced exploration, qualitative and semi-quantitative total analysis samples shall be collected separately or selected from the duplicate samples for basic analysis, from different spatial locations of the orebody, with different ore types (or grade), as well as the ore and possible ore-bearing rocks such as wall rocks and alteration zones. For total analysis of samples, appropriate analytical methods are used for qualitative and semi-quantitative total analysis to provide a basis for determining total elements analysis, combined composite analysis and basic analysis items.

8.7.2.2 Total elements analysis

A total elements analysis should be carried out to accurately determine the various components (except trace minerals) and the contents of ore minerals. The total content of the analysis results of each component should be close to 100%. From the general exploration stage, on the basis of qualitative and semi-quantitative total analysis, total elements analysis is conducted on representative samples collected separately from the main orebody based on different ore types (ore grades), or samples taken from the composite analysis duplicates, providing basis for the research of mineral composition and chemical properties, and determination of the basic analysis and composite analysis items.

8.7.2.3 Basic analysis

The basic analysis should be carried out to identify the content and variations of useful and certain harmful components in the ore, as the main basis for the delineation of the orebody and mineral resources estimation (except uranium). The requirements for sample collection and analysis items are as follows:

- a) Continuous sampling of orebody should be conducted according to the type and grade of ore in exploration engineering. In general, continuous sampling (control samples) should also be conducted for the internal waste and the roof and floor wall rocks adjacent to the orebody to control the boundary between the orebody and the internal waste and wall rocks, and identify the impact of the internal waste and wall rocks mixing on the technical performance of ore processing.
- b) The length of basic analysis samples should be determined reasonably, based on the relationship between the orebody and the wall rocks and internal waste (gradual or abrupt change), the thickness of the orebody, content change of the components of the basic analysis samples, technical parameters and variables for ore deposit, such as the minimum mining thickness and minimum thickness of separable internal waste. The lengths of the samples should be the same as much as possible, and the internal waste be eliminated effectively, and the ore bodies be delineated reasonably.
- c) Channel sampling is usually employed for trenching, costeaning, and tunneling. Borehole core is usually sawn (cut) in half for sampling. Powder (chip) samples are usually collected from the air reverse circulation drilling boreholes. Other representative sampling methods can also be selected through tests.
- d) Samples are generally taken continuously in the waist line of the transverse adit, or on both sides if the mineralization is not uniform, and samples are taken from the tunnel heading face or roof along the dike adit, with the spacing of the samples depending on the degree of uniformity of the mineralization.
- e) The specification of the cross-section of the channeling samples should be determined by experiments based on the uniformity of mineralization, the degree of change in the mineral composition of the ore, the ore structure, and the difference in the physical properties of ore, etc. Diamond cutter should be used for core sawing (cutting). When the borehole diameters or recovery rates of each round vary greatly, they should be sampled separately.
- f) The basic analysis items are generally the main components of mineralization. All useful components involved in the comprehensive technical parameters and variables for ore deposit should be included in the basic analysis items. The coexisting useful components should generally be included in the basic analysis items.

8.7.2.4 Composite analysis

Composite analysis should be carried out to systematically determine the content of associated useful, beneficial and harmful components and certain paragenetic commercial minerals in ore, as well as the distribution in the orebody. It is a basis

for evaluating the comprehensive economic value of associated useful components and certain paragenetic commercial minerals, and the impact of useful and harmful components on the technical performance of ore processing and metallurgy and the quality of mineral products. It is also a basis for estimating the mineral resources of associated minerals and certain paragenetic commercial minerals. The sample collection and analysis requirements are as follows:

- a) Composite samples should be taken from the duplicate samples of basic analysis according to the orebody and ore type (grade). The samples are composited according to the engineering work or block, or the profile, level, and even orebody, based on the represented true thickness ratio (for borehole drilling, when samples are composited according to the engineering work, sample length ratio could be used).
- b) The weight of a single composite sample is generally 200g–400g, of which 1/2 is kept as duplicates, and the other 1/2 is sent as normal samples for testing.
- c) The analysis items of the composite samples are determined based on the results of basic analysis, qualitative and semi-quantitative total analysis, total elements analysis, combined with the geological characteristics of the deposit and the technical performance of ore processing and metallurgy. To understand the relationship between the associated components and the main components, or when the composite analysis results are needed to classify the type of ore, some basic analysis items should also be included in the composite analysis items.

8.7.2.5 Phase analysis

Phase analysis should be carried out to determine the occurrence, content and distribution rate of useful, beneficial and harmful components in ore, as the basis for classifying the natural type and industrial type of ore, evaluating the quality of ore, and studying the natural zoning of the deposit. The requirements for sampling are as follows:

- a) Phase analysis samples are usually taken from the surface down or along faults and fracture zones until the primary zone is defined. But when different occurrences of useful components have a great impact on the performance of primary ore processing and metallurgy, samples should also be collected within the primary zone.
- b) Phase analysis samples are usually taken specifically, which may also be collected from the duplicate samples of basic analysis when the analysis quality requirements are met. Sampling and analysis must be carried out in a timely manner to prevent sample oxidation from affecting quality.

8.7.2.6 Monomineralic or artificial concentrate analysis

Monomineralic or artificial concentrate analysis should be conducted to identify the occurrence, distribution, contents of rare and dispersed elements and precious metallic elements, as well as the relationship with the main metallic elements. Samples for monomineralic or artificial concentrate analysis are generally obtained from the laboratory by various physical sorting methods. The location and quantity

should be determined according to the actual needs. When used for resource estimation, composite samples can be collected on engineering works or ore blocks.

8.7.2.7 Silicate analysis (petrochemical analysis)

Silicate analysis should be carried out to study the rules of element migration, lithogenesis and petrofacies in the region to study the relationship between rock and mineralization. Silicate analysis can only be carried out when the silicate samples of rocks or wall rocks are identified as representative by thin sections. During research of the substances bringing in or taking out, the mass of oxides of the same volume should be compared. The bulk density of the samples need be measured before the analysis.

8.7.2.8 Analysis of harmful components of rocks

In order to identify the harmful components and the contents in the wall rocks and internal waste, and evaluate the possible impact on the ecological environment during the mining process, and develop corresponding prevention and control measures, the analysis of harmful components of rocks should be carried out.

At the detailed exploration stage, a certain quantity of samples should be taken to analyze the harmful components in the rocks according to the lithology of the wall rocks and internal waste, which provides a basis for identifying the harmful components in the wall rocks and internal waste that may have an impact on the environment. At the advanced exploration stage, infill boreholes with many types of wall rocks and internal waste and typical representativeness should be selected for analysis of harmful components in various wall rocks and internal waste, providing a basis for evaluating the impact of harmful components in wall rocks and internal waste on the environment.

8.7.3 Sample preparation

Sample preparation generally follows a step-by-step splitting or linkage line process. Regardless of which process is used, the samples should be split according to Qeqott formula, and the total loss rate of the sample should not be greater than 5%, and the error for each reduction should not be greater than 3% of the original mass.

8.7.4 Analytical quality check

8.7.4.1 The internal check of chemical analysis is mainly to check the accidental errors of sample preparation and analysis, and the external check is to check the systematic errors of sample analysis. All the basic analysis and composite analysis results related in orebody delineation and resource estimation shall be subject to internal and external checks. Some phase analysis results shall also be subject to internal and external checks. The internal check and external check of the basic analysis and composite analysis results should be carried out by batches and stages.

8.7.4.2 Internal check samples are taken from the coarse duplicates of the basic analysis samples and composite samples, and samples with very high grade should be included. The quantity of internal check samples for basic analysis should be not less than 10% of the total number of samples. When sample quantity to be checked is large or many test results prove that the quality meets the requirements, the quantity of internal check samples can be appropriately reduced, but not less than 5%. The quantity of composite samples for internal check shall not be less than 5% of the total number of samples to be checked.

8.7.4.3 The external check samples shall be taken from the residual qualified internal check samples, which are generally 5% of the total number of basic samples related in the resource estimation. When the quantity of basic samples related in the resource estimation is large, the proportion of external check samples can be reduced, but should not be less than 3%. The internal and external check pass rates of each batch (stage) of samples shall not be less than 90%.

8.7.4.4 When the pass rate of the external check samples does not meet the requirements or the original analysis results have systematic errors, and the original laboratory and the external laboratory cannot identify the reasons or have different opinions on the cause of the error, the original analysis (basic analysis and composite analysis) laboratory and the external laboratory should negotiate to determine a third party for arbitration analysis. Decisions can be made according to the arbitration analysis results.

8.8 Collection and test of ore processing and metallurgy technical performance samples

8.8.1 The research level of the ore processing and metallurgical technical performance test shall be determined according to the test level requirements and industrial utilization requirements of different exploration stages, which shall be carried out in compliant with the relevant specifications.

8.8.2 Before the collection of samples for ore processing and metallurgical technical performance test, the delivery institute unit shall work closely with the test organization, if necessary, to seek advice from the design organization, jointly prepare the sampling design report, which shall be approved by the exploration investors before execution.

8.8.3 The representativeness of ore type, grade, texture and structure, and spatial distribution shall be considered when taking the technical performance test samples for the ore processing and metallurgical technical performance test. When there are coexisting and associated useful minerals in ore, the representativeness of samples should be considered, to learn the comprehensive recovery process during the test. When collecting samples for laboratory process test, laboratory expanded continuous test and pilot plant test are collected, the influence of mixing of waste rock and ore dilution during mining should also be considered. When different types and grades

of ore cannot or do not need to be mined or processed separately, only mixed ore samples can be taken (the proportion of each grade and type of ore samples should be representative) for mixed ore sample processing and metallurgy technical performance test.

8.8.4 The ore processing and metallurgical technical performance test that provides the basis for mine construction design should generally be carried out on the basis that the corresponding tests have been carried out on the ore of the entire exploration area and has basically identified the ore processing and metallurgical technical performance. Test samples are usually taken in the initial mining area (section to be mined first).

8.8.5 Depending on the nature of the ore, different processing and metallurgy methods or the two (or more) methods for combined processing and metallurgical process should be studied and compared, to recommend the ore processing and metallurgy process. The test requirements are as follows:

- a) The amenability test focuses on exploring and studying the amenability of each type and grade of ore and the availability of the main useful components.
- b) The laboratory process test shall evaluate the availability of the main useful components, the comprehensive recovery of associated useful components and the possibility of removing harmful components through the processing conditions, flowsheet structure and open-circuit and closed-circuit tests, and recommend the best processing flowsheet and conditions.
- c) Laboratory expanded continuous test should be conducted under one or more of the recommended processes in the laboratory process test, which are arranged in a series of continuous operations under similar production conditions. The stability of the processing test conditions is realized in dynamics, to obtain the stable test indicators.
- d) A special pilot plant (workshop) should be used for pilot plant test. Industrial tests shall be conducted according to the production operation condition to obtain close test result.
- e) The existing production workshop or production equipment will be used for the industrial tests, and the partial or whole process production tests shall be conducted to obtain the results under production conditions.

8.9 Collection and test of rock (ore) physical and technical properties test samples

8.9.1 The physical and technical properties of the rock (ore) or soil should be tested during the detailed exploration and advanced exploration stages. The test samples should be representative, focusing on the roof and floor of ore and reflecting the main characteristics of various rock (ore) or soil. Sampling and testing items generally include density, moisture, porosity, loosening coefficient

of the rock (ore) or soil, as well as the compression, shear, tensile strength of the wall rocks and the roof and floor of the orebody, etc.

8.9.2 The samples for density measurements should be collected according to the ore type and grade, and should be representative in terms of spatial distribution and quantity. The specific density samples should be sealed on site with wax. The samples of each major ore type or grade shall not be less than 30 pieces. For the loose ore or ore with many fractures and pores (such as oxidized ore, weathered crustal ore, etc.), 2 to 5 pieces of bulk density samples shall be collected according to the type or grade of ore. The bulk density is measured and used to correct the specific density, or directly participate in resource estimation. The volume of the specific density sample of the metallic and nonmetallic ore is generally $60\text{--}120\text{cm}^3$, and the volume of the bulk density sample is generally not less than 0.125m^3 . When samples cannot be collected during the general exploration stage, the number of the density samples can be determined according to the actual situation.

8.9.3 The grade, moisture and porosity (oxidized ore) of the main elements should also be measured when the density of ore is tested. When the density correlates with the content of an element, the grade of the element should be analyzed. When the moisture is greater than 3%, the density values should be corrected by moisture.

8.10 Raw data preservation, logging, recording and report preparation

8.10.1 All exploration engineering shall be photographed and the on-site image data should be retained before the start of construction and after rehabilitation of site. Core photographs of the rock, ore and samples, and other data should also be numbered and saved on CD, as raw data to be saved.

8.10.2 At each stage of exploration, the original logging shall be carried out on site in a timely manner to objectively, accurately and completely reflect the observation geological phenomena. The original logging data shall be checked for quality acceptance and accepted and comprehensively sorted out in a timely manner. After the completion of each work, the original data and comprehensive data shall be submitted in a timely manner, with clear drawings and concise text. The text and drawings should be consistent. The computer is used for logging, and the revision control should be conducted. The specific execution shall be done in accordance with the relevant regulations and requirements.

8.10.3 The exploration report shall be completed, with emphasis and correct data, and the quality should be in line with the relevant specifications.

9 Feasibility assessment

9.1 General requirements

9.1.1 During the general exploration, detailed exploration and advanced exploration stages, the feasibility assessment should be carried out in parallel with the exploration and the assessment level can be upgraded dynamically, so that

the exploration can be closely connected with the next stage exploration or mine (mine field) construction, to reduce investment risks on exploration and mine (mine field) development and improve the comprehensive economic, social and ecological benefits of exploration and development.

9.1.2 According to the level of the study, the feasibility assessment is divided into three stages: scoping study, pre-feasibility study and feasibility study.

9.1.3 Depending on the level of the study, geology, mining, processing and metallurgical, infrastructure, economic, marketing, legal, environment, community and government policy factors, etc. should be considered for the feasibility assessment to analyze the possibility (investment opportunity) and feasibility of the mine (mine field) construction. Conclusions shall be made on whether it is appropriate to upgrade from lower exploration stage to a higher exploration stage, or whether mine development is feasible.

9.2 Scoping study

9.2.1 Scoping study is a brief study assessing the technical feasibility and economic viability of the project by understanding and analysis of mining, processing, metallurgical, infrastructure, economic, marketing, legal, environment, community and government policy factors. Conclusions are made on whether the development of the deposit is possible and whether it is necessary to move to the next stage of exploration.

9.2.2 The Scoping study can be carried out on the basis of all exploration level.

9.3 Pre-feasibility study

9.3.1 Pre-feasibility study is a preliminary study assessing the technical feasibility and economic viability of the project by analysis of mining, processing, metallurgical, infrastructure, economic, marketing, legal, environment, community and government policy factors. Evaluation is made on whether the mine (mine field) construction is feasible, providing the basis for decision-making for the mine construction project.

9.3.2 The pre-feasibility study shall be carried out on the basis of detailed exploration and the level of work above.

9.4 Feasibility study

9.4.1 Feasibility study is a detailed study assessing the technical feasibility and economic viability of the project by analysis of mining, processing, metallurgical, infrastructure, economic, marketing, legal, environment, community and government policy factors. A detailed evaluation is made on whether the mine (mine field) construction is feasible, providing the basis for the investment decision-making for the mine (mine field) construction, the determination of the construction plan, and the mine construction preliminary design, etc.

9.4.2 The feasibility study is usually carried out on the basis of advanced exploration.

10 Classifications of mineral resources and mineral reserves

10.1 Mineral resources

10.1.1 Classification of mineral resources

Mineral resources are classified, in accordance with GB/T 17766, in order of increasing the geological confidence, into inferred, indicated and measured resources. Classifications of mineral resources and mineral reserves, and the conversion relationships are illustrated in Annex B.

10.1.2 Inferred resources

The Inferred resources are the mineral resources that are delineated and estimated on the basis of sparse sampling, and the extrapolated mineral resources from the indicated resources or the measured resources. The spatial distribution, shape, orientation, and continuity of the orebody are reasonably inferred. The quantity, grade or quality are estimated on the basis of limited sampling and data. The geological confidence of inferred resources is relatively low. The specific conditions for geological confidence are as follows:

- a) To preliminarily control the shape, general orientation and spatial location of the orebody.
- b) To preliminarily control the properties, orientation and distribution of large folds, faults and fractured zones that control and damage the orebody; and roughly control the lithology, orientation and distribution of the major magma, ore-bearing rock, internal waste, and non-ore area rock.
- c) To preliminarily identify the occurrence and distribution of the useful and harmful components affecting the performance of ore processing and metallurgy, and ore type (grade).

10.1.3 Indicated resources

The Indicated resources are the mineral resources that are delineated and estimated on the basis of systematic sampling. The spatial distribution, shape, orientation, and continuity of the orebody are primarily determined. The quantity, grade, or quality are estimated on the basis of fairly sufficient sampling and data. The geological confidence of the indicated resources is relatively high. The specific evidence for geological confidence is as follows:

- a) To fundamentally control the shape, orientation and location of the orebody.
- b) To fundamentally control the properties, occurrence and distribution of large folds, faults and fractured zones that control or damage the orebody and affect the

levels; and preliminarily control the lithology, orientation and distribution of the major magma, ore-bearing rock series, internal waste and non-ore area rock.

c) To basically identify the occurrence and distribution of the useful and harmful components affecting the performance of ore processing and metallurgy, as well as the ore type (grade); and that if selective mining is necessary, to basically define the ore type (grade) and the spatial range.

10.1.4 Measured resources

The measured resources are the mineral resources that are delineated and estimated by infilled sampling on the basis of the systematic sampling. The spatial distribution, shape, orientation, and continuity of the orebody are defined. The quantity, grade, or quality are estimated on the basis of sufficient sampling and detailed data. The geological confidence of the measured resources is high. The specific conditions for geological confidence are as follows:

- a) To control in detail the shape, orientation and spatial location of the orebody.
- b) To control in detail the properties, orientation and distribution of large folds, faults and fractured zones that affect the mining of the levels (elevations); and fundamentally control the lithology, orientation and distribution of the major magma, ore-bearing rock series, internal waste and non-ore area rock.
- c) To define in detail the occurrence and distribution of the useful and harmful components affecting the performance of ore processing and metallurgy, as well as the ore type (grade); and if selective mining required with permitted geological conditions, to define in detail the ore type (grade) and related spatial range.

10.2 Mineral reserves

10.2.1 Classification of mineral reserves

Mineral reserves are classified into the categories of probable mineral reserves and proved mineral reserves in order of increasing geological confidence and the certainty degree of the modifying factors, including the mining, processing, metallurgical, infrastructure, economic, marketing, legal, environment, community, and government policy etc.

10.2.2 Probable mineral reserves

Probable mineral reserves are the mineral reserves that are estimated from the indicated resources, based on a pre-feasibility study, or a feasibility study, or an equivalent technical and economic assessment. Alternatively, probable mineral reserves can be estimated from the measured resources, with some uncertainties in some modifying factors.

10.2.3 Proved mineral reserves

Proved mineral reserves are the mineral reserves that are estimated from the measured resources, based on a pre-feasibility study, or a feasibility study, or an equivalent technical and economic assessment.

10.3 Classification modifying of mineral resources and mineral reserves

During the process of exploration, when the type of deposit (orebody) exploration is changed and the exploration control and research level is not in conformity with the corresponding conditions of mineral resources, the classification of mineral resources shall be modified. If the mineral reserves need to be estimated, the classification of mineral reserves shall be modified accordingly through feasibility assessment.

11 Estimation of mineral resources and mineral reserves

11.1 Technical parameters and variables for ore deposit

11.1.1 The technical parameters and variables for ore deposit are proposed for the ore quality and mining technical conditions in a certain period of technical and economic conditions, which are the basis for the delineation of orebody and estimation of mineral resources and mineral reserves. It usually includes general technical parameters and variables for ore deposit, and technical parameters and variables for ore deposit formulated by demonstration. The specific content and general requirements of technical parameters and variables for ore deposit are specified by the specifications of the mineral type(group).

11.1.2 The general technical parameters and variables are general reference indicators issued in accordance with the relevant provisions and they are the basis for the delineation of the orebody and estimation of mineral resources in a certain period under general technical and economic conditions.

11.1.3 The technical parameters and variables for ore deposit formulated by demonstration are to follow the relevant regulations and technical standards and used for the technical parameters and variables for ore deposit of certain deposits through technical and economic analysis. The orebody delineation under the criteria is technically feasible and economically viable in mine development in the current or foreseeable future period when policy and environmental conditions permit. The demonstration and formulation of technical parameters and variables for deposit shall be carried out according to the relevant technical requirements.

11.1.4 The adoption of the technical parameters and variables for ore deposit shall be in accordance with the relevant national policies and regulations. For projects with detailed exploration or higher level of exploration, the technical parameters and variables for ore deposit formulated by demonstration are to be adopted.

11.2 Basic requirements of mineral resources estimation

11.2.1 The quality of engineering and sampling test analysis involved in orebody delineation and resource estimation shall meet the requirements of relevant regulations and specifications. All the engineering and sampling test analysis results that meet the requirements of relevant norms and regulations should be involved in orebody delineation and mineral resources estimation.

11.2.2 Application of computing technology is encouraged to establish database and three-dimensional geological models for mineral resources estimation.

11.2.3 Mineral resources estimation shall be carried out on the premise of fully studying the geological characteristics of the deposit and the mineralization and orebody-controlling factors, following the geological rules, and correctly delineating the orebody according to the technical parameters and variables for ore deposit and the rules of mineralization delineation, or the mineralization domain is correctly delineated according to the mineralization cut-off grade.

11.2.4 The orebody delineation shall be in line with geological rules, and the relationship between the orebody and other geological domains should be in accordance with geological understanding. When delineating the orebody, the geological boundaries should be outlined first, and then the orebody according to the main ore-controlling geological characteristics and the characteristics of the marker bed. Usually, the straight line should be used, and natural curve connection can also be used in wireframe of the orebody when its nature is fully understood. Regardless of the formality used, the thickness of the orebody connected between engineering shall not be greater than the actual thickness of orebody controlled by the engineering.

11.2.5 The orebody delineation starts from a single engineering project and follows the sequence of single engineering project – profile – plane or three-dimensional orebody. The thick and continuous low-grade ore should be delineated separately. Ores of different types (grades) within the orebody should be delineated separately when selective mining and processing is possible.

11.2.6 The extrapolation of the orebody should be reasonable. When the variation is obvious, the boundaries of the orebody should be extrapolated according to the variation. When the variation is not obvious or unclear, the boundaries of the orebody should be extrapolated along the extension direction of the orebody. Extrapolation is generally based on the actual distance along the strike or the dip of orebody in pinch-out (triangle extrapolation, cone extrapolation and wedge extrapolation) or in parallel (rectangular extrapolation and plate extrapolation). The specific requirements are as follow:

a) When the actual exploration engineering spacing between the exploration engineering that exposes orebody and the adjacent engineering is greater than the inferred exploration engineering spacing, or when there is no controlling engineering outside the exploration engineering that exposes orebody, the inferred resources are can be estimated at 1/2 pinch-out or 1/4 parallel of the extrapolation distance of the exploration engineering spacing of the inferred resources.

b) When the actual exploration engineering spacing between the exploration engineering that exposes orebody and the adjacent engineering is not greater than the inferred exploration engineering spacing, and when no mineralization is exposed by the adjacent exploration engineering, the mineral resources are inferred at 1/2 pinch-out or 1/4 parallel of the extrapolation distance of the actual extrapolation spacing, while the mineralization in the adjacent exploration engineering reaches or exceeds 1/2 of the cut-off grade, the mineral resources are inferred at 2/3 pinch-out or 1/3 parallel of the extrapolation distance of the actual extrapolation spacing.

c) When the grade and thickness of orebody shows a gradual variation, interpolation method is adopted for delineation of the boundaries.

d) The extrapolation range outside the marginal exploration engineering that exposes orebody shall be determined according to the variation characteristics and the influence scope of geological variables. The mineral resources are inferred at 1/2 pinch-out or 1/4 parallel of the extrapolation distance of the inferred resources extrapolation spacing, but no extrapolation shall be allowed when the boundary of the orebody is defined by meter percentile grade or $m \cdot \text{gram/tonne}$ (except for thin ore bodies defined by the meter percentile grade or $m \cdot \text{gram/tonne}$).

11.2.7 In principle, the measured resources and the indicated resources shall not be defined by the extrapolated boundaries. But when orebody is exposed from the sampling between the inferred exploration work and the indicated exploration work from the tunnel along the vein, or when the sampling between the inferred exploration work and the indicated exploration work from the inside and outside of the line shows limited changes for thickness and grade of the orebody (the thickness is stable, and the grade is uniform or relatively uniform), 1/4 of the basic exploration spacing can be extrapolated in parallel and the indicated resources can be estimated.

11.2.8 When outliers are present in the orebody (or mineralized domain), capping should be conducted unless the mineral resources estimate method can offset the influence of outliers. Generally, when the grade of the single sample of a useful component in the orebody is 6 to 8 times higher than the average grade (the arithmetic means of all the single samples in the orebody before capping) of the orebody, it is regarded as an outlier, which are respectively defined 6 times, 7 times and 8 times when the useful components vary uniformly, relatively uniformly, and nonuniformly. The outlier is usually replaced by the average grade of the block where the outlier is located. When the thickness of single engineering is 3 times greater than the average thickness of the orebody, the average grade of orebody can also be used alternatively for the project. After capping for higher grades, the orebody should be re-examined and if outliers still exist, re-capping for higher grades should be conducted until all outliers are eliminated.

11.2.9 The mineral resources estimation shall be conducted on the basis of the characteristics of the orebody (shape and internal texture of orebody, orientation and the changes, thickness and grade changes, etc.), the distribution of the sampling

and sample quantity, etc. It shall be based on the actual measured values to reasonably determine the mineral resources estimation parameters. The selection and implementation of resource estimation methods shall be carried out in accordance with the relevant regulations.

11.2.10 For a multi-mineral orebody, if comprehensive technical parameters and variables for ore deposit adopted, the orebody should be delineated, and its mineral resources should be estimated, according to the comprehensive technical parameters and variables for deposit. For the multi-mineral orebody with no comprehensive technical parameters and variables for deposit adopted, the orebody should be delineated, and its mineral resources estimation should be conducted based on the technical parameters and variables for ore deposit of the main minerals and paragenetic commercial minerals, while the multi-mineral orebody between the cut-off grade and the minimum mining grade are classified as associated minerals or industrial grade paragenetic commercial minerals. When the variability of the main minerals and paragenetic commercial minerals are similar and there is no need for selective mining and processing, mixed delineation may be adopted (if one of the components meet the requirements of the technical parameters and variables for ore deposit, it is delineated into the same orebody), but their respective mineral resources should be estimated separately.

11.2.11 The mineral resources are classified according to the orebody. If necessary, the mineral resources estimation is conducted according to the ore type or grade. For the associated minerals, the resource estimation is conducted by blocks.

11.3 Basic requirements of mineral reserves estimation

Based on analyzing and studying factors (referred to as modifying factors) of the project such as the mining, processing, metallurgical, infrastructure, economic, marketing, legal, environment, community and government policy factors, the pre-feasibility study, feasibility study or equivalent technical and economic assessment indicates that when the mineral resources development is technically feasible, economically viable and environmentally permissible, the measured resources and the indicated resources can be converted into mineral reserves after deducting design losses and mining losses.

11.4 Category identification of mineral resources and mineral reserves

According to the exploration control and research level of different ore bodies and different sections (blocks), the geological confidence should be objectively evaluated, combined with the level and conclusions of the feasibility assessment, to identify the category on the mineral resources and mineral reserves, which shall be implemented in accordance with the GB/T 17766.

11.5 Estimation results of mineral resources and mineral reserves

The estimation results of mineral resources and mineral reserves should be represented in the form of text, diagrams and tables, and classified into available quantity, mined quantity (if there is any) and cumulatively identified quantity. Main minerals, paragenetic commercial minerals and associated minerals are also classified according to industrial types (or grades) of different ores. Different category of mineral resources and mineral reserves shall be clearly illustrated, and the illustrated content depends on the characteristics of ore type, which shall be implemented according to the corresponding mineral specifications and related requirements.

Annex A
(Informative)

Reference Requirements for the Proportions of Mineral Resources Estimate at Each
Stage of Exploration for Metallic and Non-Metallic Deposits

The mineral resources defined in each exploration stage of the metallic and nonmetallic deposits and the reference requirements for the proportions are shown in Table A. 1.

Table A. 1:Reference Requirements for the Proportions of Mineral Resources Estimate
at Each Stage of Exploration for Metallic and Non-Metallic Deposits

Complexity		General				Complex			
Resources Scale		Large-medium scale		Small scale		Large-medium scale		Small scale	
General Exploration	types of mineral resources	Inferred Resources							
Detailed Exploration	types of mineral resources	Indicated + Inferred Resources						Inferred	
	Minimum requirement of proportion (%)	Metallic deposit: Indicated 20~30; Non-metallic deposit: Indicated 30~50							
Advanced Exploration	types of mineral resources	Measured + Indicated + Inferred			The level of advanced exploration is not required to be used as the basis for mine construction design				
	Minimum requirement of proportion (%)	Measured	Measured + Indicated	Inferred					
		10~20	50~60						
Complex and Small Scale Deposit for Mine Construction Design	types of mineral resources				Indicated + Inferred				Inferred
	Minimum requirement of proportion (%)				Indicated	Inferred	Indicated	Inferred	
					50~60		30~60		
Note 1: The proportion of mineral resources in the table is the comprehensive reference ratio requirement for the exploration of each mineral. The reference ratio requirements for specific mineral types can be formulated based on their own characteristics and refer to this table. Note 2: For deposits at advanced exploration stage, smaller complex deposits for mine construction design, it is encouraged to reasonably determine the proportion of mineral resources through demonstration in accordance with the principle of “guaranteeing the repayment of capital and interest in the first mining area and controllable risks in mine construction” . Note 3: Complex deposits refer to the deposits of Type III, for which it is difficult to estimate the measured resources with the measured exploration engineering spacing, or the indicated resources with the indicated exploration engineering spacing. Note 4: For small and complex deposits, only the inferred resources are estimated for exploring while mining in the production stage of the mine.									

Annex B (Informative)

Classifications of Mineral Resources and Mineral Reserves and Their Conversion Relationships

B.1 Classifications of Mineral Resources and Mineral Reserves and Their Conversion Relationships

The classifications of mineral resources and mineral reserves and their conversion relationships are illustrated in Figure B.1.

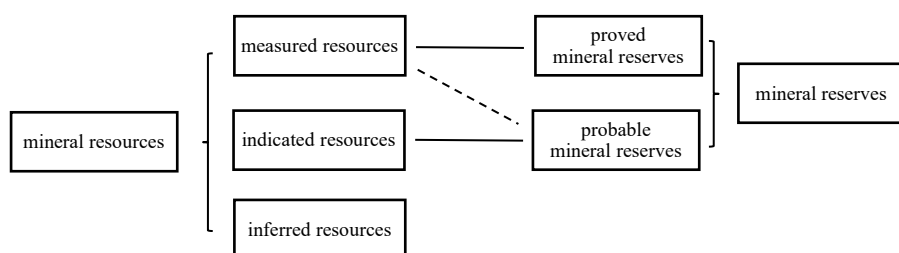


Figure B.1: Classifications of Mineral Resources and Mineral Reserves and the Conversion Relationships

B.2 Relationships between mineral resources and mineral reserves

B.2.1 Mineral resources and mineral reserves may be converted in either direction.

B.2.2 Measured resources and indicated resources may be converted to mineral reserves.

B.2.3 At least a pre-feasibility study or an equivalent technical and economic assessment must have been done to support the conversion from mineral resources to mineral reserves.

B.2.4 In the case that any change(s) in modifying factors render the project no longer technically feasible and economically viable, mineral reserves should be converted back to mineral resources in due course.

Bibliography

- [1] GB 12719-1991 Exploration specification of hydrogeology and engineering geology in mining areas.
- [2] GB/T 33444-2016 Specification for exploration of solid mineral resources
- [3] GB 50197-2015 Code for design of open pit mine of coal industry
- [4] GB 50215-2015 Code for design of mine of coal industry.
- [5] GB 50771-2012 Code for design of nonferrous metal mining.
- [6] GB 51060-2014 Code for exploration of hydrogeology in nonferrous metal mines.
- [7] DZ/T 0078-2015 Procedures for original geological record of solid mineral exploration.
- [8] DZ/T 0130-2006 The specification of testing quality management for geological laboratories.
- [9] DZ/T 0275.1-2015 Specification Identification of rock and mineral, Part1: General rules and regulations
- [10] DZ/T 0287-2015 Technical regulations for mine geo-environment monitoring.
- [11] HJ 651-2013 Technical Specifications for eco-environmental protection and reclamation for mining (On trial).
- [12] T/CMAS 0001 Guidelines for the Green Exploration
- [13] China Geological Survey 1:50,000 Regional Geological Survey Guidelines (trial).
- [14] China Geological Survey 1:50,000 Coverage Area Regional Geological Survey Guidelines (trial).
- [15] Department of Mineral Reserves, Ministry of Land and Resources, New changes in Geological Exploration Norms for Solid Minerals. Geological Press
- [16] Hou Deyi, Prospecting and Exploration Geology. Beijing: Geological Press, 1984.11
- [17] Hou Deyi, Liu Peng'e, Li Shouyi, and Ye Songqing, Mineral Exploration. Beijing: Geological Press, 1997.11
- [18] Yu Runcang, Mining Engineer's Handbook. Beijing: Metallurgical Industry Press, 2009.3