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# Specifications for Metallurgic, Chemical Limestone and Dolomite, Cement-Materials Mineral Exploration

冶金、化工石灰岩及白云岩、水泥原料矿产地质勘查规范



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# Specifications for Metallurgic, Chemical Limestone and Dolomite, Cement-Materials Mineral Exploration

## 1 Scope

This Standard specifies the degree of exploration study, exploration quality, classification and type condition of resources/reserves, estimation of resources/reserves, etc. for metallurgical, chemical limestone and dolomite, cement-material mineral (calcareous material, clay material, and siliceous material)[1)]; and provides the deposit exploration type for analogy, and exploration engineering spacing for reference.

This Standard is applicable to the metallurgic, chemical limestone and dolomite, cement-materials mineral exploration, resource/reserves estimation; applicable to the acceptance and review for the exploration design and exploration result report of metallurgic, chemical limestone and dolomite, cement-material mineral; can also serve as the basis for assessing and estimating the mineral resources/reserves during the financing and the like activities of mining rights transferring, and mineral exploration and mining.

## 2 Normative References

The provisions in following documents become the provisions of this Standard through reference in this Standard. For dated references, the subsequent amendments (excluding corrigendum) or revisions do not apply to this Standard, however, parties who reach an agreement based on this Standard are encouraged to study if the latest versions of these documents are applicable. For undated references, the latest edition of the referenced document applies.

GB/T 13908-2002 General Requirements for Solid Mineral Exploration

GB/T 17766-1999 Classification for Resources/Reserves of Solid Fuels and Mineral Commodities

GB/T 12719-91 Exploration Specification of hydrogeology and Engineering Geology in Mining Areas

[1)] Cement-material mineral generally includes: calcareous material – limestone, argillaceous limestone, marble; clay material – clay, loess, mudstone, silt rock, shale, phyllite; siliceous material – sand, sandstone.

# 3 Target Tasks of Exploration

The exploration work can be divided into four phases, namely, pre-survey, general survey, detailed survey, and prospecting. The target tasks in each phase are as follows:

**3.1** Pre-survey phase: through comprehensive study of geological data in the area, preliminary field observation, very small amount of engineering verification, analogy and prediction of the known deposit with the similar geological characteristics, propose the area with larger mineral resources potentials for the general survey.

**3.2** General survey phase: through adopting outcrop inspection, geological mapping, limited number of sampling work, and the like field work against the area with larger mineral source potentials confirmed in the pre-survey phase, generally find out the geology and tectonics in the general survey area; generally understand the orebody shape, production condition, and quality characteristics; generally learn exploring technology of the deposit; conduct the mineral processing and separation analogy study; propose whether it is worth for the further detailed survey, and encircle the range for the detailed survey area.

**3.3** Detailed survey phase: adopt several exploration methods and measures against the detailed survey area encircled by the general survey; take certain network degree system to sample; basically identify the geological and tectonic characteristics, and control situation for the orebody, which mainly includes orebody shape, occurrence, size, and mineral quality; basically confirm the continuity of the orebody; basically find out the technical conditions of deposit mining; conduct the mineral processing and separation analogy and laboratory flow test study; make the assessment for whether it has industrial value or whether it can be used in the near future. If necessary, encircle exploration range; and provide basis for pre-feasibility study, master mine planning, and preparation of mine project proposals. For the mining areas that directly provide mining and utilization, it shall meet the requirements of mine construction design.

**3.4** Prospecting phase: through encrypting various sampling projects against the exploration area proposed by the detailed survey, identify the deposit geological characteristics in detailed; confirm the orebody shape, occurrence, size, change regularity of down-strike and inclination, spatial location and ore quality characteristics; confirm the continuity of orebody; find out the technical conditions of orebody mining; so that provide basis for the feasibility study or mine construction design.

# 4 Study Degree of Exploration Work

## 4.1 Geological study

### 4.1.1 area geology

occurrence, thickness, ore composition, ore type and distribution; generally, identify the grain size, mineral composition, chemical composition of loose clay material, siliceous material, and the plasticity of clay material; generally, learn the type and distribution of ore-bearing rock, as well as the mineral composition, chemical composition, structure and tectonics of ore-bearing rock.

During the detailed survey phase, it shall basically identify the orebody shape, scale, occurrence, thickness and change regularity; basically identify the ore type, grade, distribution and change regularity; basically identify ore mineral composition, chemical composition, structure and tectonics; study the grain size, mineral composition, chemical composition of loose clay material and siliceous material, as well as the plasticity of clay material; basically identify the ore-bearing rock type, scale, occurrence, distribution regularity; basically identify the ore-bearing rock mineral composition, chemical composition, structure and tectonics.

During the prospecting phase, it shall carefully identify the orebody shape, scale, occurrence, thickness; carefully identify ore type, grade and distribution; carefully identify ore mineral composition, chemical composition, structure and tectonics; carefully identify the ore-bearing rock type, scale, and occurrence.

### 4.2 Test requirements for ore processing technology

**4.2.1** During the pre-survey phase, it shall collect ore processing technology related information for analogy study.

**4.2.2** During the general survey phase, it shall compare the ore processing technologies, then evaluate whether it can be able to serve as industrial raw materials.

**4.2.3** During the detailed survey and prospecting phases, it shall test, according to the demands of the investors, the ore processing technology.

**4.2.3.1** Test requirements for metallurgic, chemical limestone and dolomite processing technology.

Wear-resistant and pressure-resistant test. Generally, this test is conducted for melting limestone and dolomite in the metallurgical industry. The specimen specification is of 5cm×5cm×5cm.

Calcination test. Generally, this test adopts semi-industrial scale. If there is similar processing technology data, they can be confirmed through analogy.

Water-wash test. Through the water-wash test, confirm whether to increase the ore-washing equipment. It aims to improve the ore quality, and ensure that the ore can meet the requirements after being crushed and ground.

**4.2.3.2** Test requirements for cement material process performance. Verify the possibility of ore utilization through the test. When it is necessary for the test, it shall

**4.3.2.2** During the general survey phase, it shall mainly collect the engineering and environmental geology data; generally, identify the engineering geological conditions in the mining area; so that provide the basis for further work.

**4.3.2.3** During the detailed survey and prospecting phases.

a) Test the physical properties of the representative rock-ore.

b) Study the rock nature, occurrence, distribution; study the combination relationship between geological tectonics and rock structure surface, hydrogeological condition, rock weathering degree, karst characteristics, etc.; describe the stability of stope slope, so that predict the possible major engineering geology problems and sections.

c) Conduct the elastic wave test against the loose orebody.

d) Collect the seismic data in the area to evaluate the stability of the area; predict the adverse environmental geology problems like rock avalanches, landslides, well spring dry, surface water and groundwater pollution, and water intrusion due to factors like exploration, etc.; study their possible formation conditions and distribution range, and propose the protection recommendations.

### 4.4 Comprehensive exploration and evaluation

During the pre-survey phase, it shall generally learn the occurred characteristics and the possibility of comprehensive utilization of economy for the symbiotic and associated minerals with industrial value.

During the general survey phase, it shall generally identify the occurred characteristics and the possibility of comprehensive utilization of economy for the symbiotic and associated minerals with industrial value.

During the detailed survey and prospecting phase, according to the principles of satisfying the investor demands and fully utilizing the resources, it shall comprehensively explore and evaluate the ore-bearing rock, vein rock, overburden, wall rock and the like symbiotic and associated minerals with industrial value, social and economic benefits confirmed in the exploration range, as well as the multi-industrial use of the raw materials.

### 4.5 Adopt new technology and new method

In combination with the actual conditions of mining area, on the premise of economy, rationality and reliability, it shall adopt various new exploration technologies and new methods; so that continue to improve the exploration study degree and achievement quality.

exploration work.

**5.2.4** During the detailed survey phase, it shall arrange the system sampling engineering to control against the orebody generally identified in the general survey phase; the engineering spacing shall be confirmed according to the exploration type; the adopted engineering spacing is the basic network degree of the detailed survey, also evaluate the control of mineral resources/reserves engineering density.

**5.2.5** During the prospecting phase, it shall encrypt the system sampling engineering spacing of the detailed survey phase. The engineering spacing is to evaluate the proven mineral resources/reserves engineering density.

**5.2.6** Reference engineering spacing table:

The limestone and dolomite mine exploration engineering reference spacing can refer to Table B.2 in Appendix B.

The clay material, siliceous material exploration engineering reference spacing can refer to the Table B.3 in Appendix B.

### 5.3 Confirmation of control degree

**5.3.1** Firstly, it shall control the overall distribution and correlation of the orebody in the exploration range. For the deposit to be opencast mined, it shall focus on systematically controlling the boundary around the orebody, and orebody boundary on the bottom of the stope; for the deposit to be mined underground, it shall focus on controlling the two ends, upper and lower boundaries, extension of the main orebody.

**5.3.2** For the proven mineral resources/reserves, its main orebody shall be encircled by the encrypted engineering on the basis of detailed survey and control; its quantity shall meet the requirements of returning the principal for the first-phase mine construction and design.

**5.3.3** For the controlled mineral resources/reserves, it shall basically identify the geological characteristics of the orebody, have the system engineering control; its quantity shall meet the requirements of reaching the minimum service life of the mine.

**5.3.4** For the inferred quantity of mineral resources, it shall initially identify the geological characteristics of the orebody, have a small amount of engineering control; meet the requirements of vision planning of the mine.

**5.3.5** For the predicted amount of mineral resources, it shall evaluate according to the data obtained from a very small number of verification engineering; provide the basis for the macro-decision-making of the area vision.

and distribution of fault and broken belt, etc.

Generally, do the radioactive examination against the mining area, if any abnormalities are found, further work shall be carried out.

The geophysical work quality shall meet the requirements of relevant regulations and specifications; its achievements shall be described in the exploration geological report.

### 6.4 Chemical sampling

#### 6.4.1 Basic analysis sampling

The basic analysis sample shall be performed stratified and multi-stage sampling in the exploration engineering. The surface sample shall be taken from the fresh rock-ore layers. The sampling method generally uses the channel method, the size of channel section is generally (3cm×2cm) ~ (10cm×5cm); the sampling in the drill hole shall take the semi-core method. The sample length for limestone and dolomite mine is 2m~4m; while the sample length for the clay material and siliceous material mine is 1m~2m. The sampling method, length and section size shall be confirmed according to the ore quality change, orebody mining thickness and ore-bearing rock removing thickness. When sampling, it shall ensure the quality, require no overlapped number, no missed mining, no re-mining, no foreign matters entered.

For the ore-bearing rock that can be distinguished by naked eye, if its thickness is greater than 0.5m, then it shall be separately sampled and analyzed.

The basic analysis items of limestone, dolomite, cement clay, and siliceous material can refer to Table C.1 in Appendix C.

#### 6.4.2 Composite analysis sampling

The composite analysis sample consists of the accessory samples by the represented thickness proportion according to the exploration engineering stratification, type, and grade.

The general representing thickness of composite analysis sample is 8m~16m; while the general representing thickness of composite analysis sample of clay material and siliceous material mine shall is about 8m.

The composite analysis items of limestone, dolomite, cement clay, and siliceous material can refer to Table C.2 in Appendix C.

For the analysis items that have been performed in the basic analysis, then they shall not be performed in the composite analysis.

When the content of harmful components in the ore is much lower than the requirements of general industrial indicators, it can select the representative profile

(engineering) to do the composite analysis.

#### 6.4.3 Spectral analysis, multi-elemental analysis sampling

The spectral analysis and multi-elemental analysis sample indicates take 1 piece ~2 pieces from the accessory sample in the basic analysis sample according to the ore strata, ore type, and grade.

The multi-elemental analysis items can be confirmed as per the spectral analysis results; generally, the multi-elemental analysis items include CaO, MgO, $SiO_2$, $Al_2O_3$, $Fe_2O_3$, $K_2O$, $Na_2O$, $SO_3$, $TiO_2$, $P_2O_5$, $Mn_3O_4$, Cl, and loss on ignition.

#### 6.4.4 Overburden, karst fillings, vein rock, near-mine wall rock sampling

Take 2 pieces ~ 3 pieces (the number of samples can be increased properly according to the requirements) of representative samples according to different types against the overburden, karst fillings, vein rock, near-mine wall rock. Its analysis items generally include CaO, MgO, $SiO_2$, $Al_2O_3$, $Fe_2O_3$, $K_2O$, $Na_2O$, $SO_3$, Cl, and loss on ignition.

### 6.5 Sample processing

The processing of chemical analysis sample includes four procedures like crushing, screening, mixing and shrinking. The sample shrinking formula is as follows:

$$Q = Kd^2$$

Where:

$Q$ – sample mass (kg);

$d$ – diameter of largest-particle sample (mm);

$K$ – shrinking coefficient.

The Value $K$ generally takes 0.05~0.1; smaller Value $K$ shall be taken for those with uniform quality; while larger Value $K$ shall be taken for those on the contrary.

The sample processing quality and quality inspection method shall be performed as per (DZ 0130.13-94) *Specification of Testing Quality Management for Geological Laboratories*, and *Rock-Ore Analysis Sample Preparation Procedures*.

### 6.6 Chemical analysis quality inspection

#### 6.6.1 Internal inspection

The sample-delivery organization shall timely extract and edit code the internal inspection sample according to the ore type and grade from the accessory sample of

judged significant; otherwise, it is insignificant.

### 6.7 Rock-ore physical properties test

#### 6.7.1 Rock-ore identification

It shall take representative sample to identify according to the ore type; it shall also take representative sample to identify the intercalation, overburden, near-ore wall rock, vein rock, etc.; The sampling quantity shall be confirmed as per the actual needs.

#### 6.7.2 Sample with small volume mass (weight), humidity

During the pre-survey and general survey phases, it shall take the analogy method to confirm the sample with small volume mass (weight), humidity.

During the detailed survey and prospecting phases, it shall take representative sample with small volume mass (weight), representative humidity sample to test; for the slope wall rock and large intercalation, it shall take small quantity of sample to test the sample with small volume mass (weight) and humidity; the total number of them shall be no less than 30 pieces.

#### 6.7.3 Compression strength

During the pre-survey and general survey phases, it shall take the analogy method to confirm the compression strength.

During the detailed survey and prospecting phases, it shall separately take 2 to 3 groups of samples to confirm the compression strength according to the ore type, intercalation and near-ore wall rock.

#### 6.7.4 Grain size analysis, plasticity index

During the pre-survey and general survey phases, it shall take the analogy method to confirm the grain size analysis, plasticity index.

During the detailed survey and prospecting phase, it shall take representative sample to do the grain size analysis and plasticity index test against the loose clay material deposit. It shall separately take according to the ore type, its quantity shall be 5%~10% basic analysis sample quantity, its total quantity shall be no less than 10 pieces. The grain size analysis generally takes the 3mm, 0.20mm, 0.074mm specification sieves; the mineral and chemical compositions of the residue-on-sieve shall be studied.

### 6.8 Original geological record, comprehensive data arrangement

#### 6.8.1 Original geological record

**6.8.1.1** The original geological record indicates the on-site record of observing and studying the geological phenomena, and record of observing and studying manners; it

economic evaluation against the deposit depending on technological and economic index or expanding index of the experiences in China's similar enterprises. So that provide basis for confirming whether the deposit exploration has the investment opportunity, whether carry out the work in the detailed survey phase, or decision-making for make the long-term planning, engineering construction planning.

### 7.3 Pre-feasibility study

The pre-feasibility study needs to make a systematic preliminary prediction of the demand, product variety, quality requirements and price trend in the domestic and foreign markets. According to the deposit scale, deposit geological characteristics, and topography of the mining area, draw lessons from the practical experience of the similar enterprise, preliminarily study and propose engineering construction scale, product type, mining area overall construction outline and process technology principle and scheme; basing on the similar enterprises, select the technological and economic indicators fitting for evaluating the current market price; preliminarily propose total investment for construction, major construction volume, main equipment, production cost, etc.; perform the initial economic analysis, encircle and calculate different types of mineral resources/reserves.

Through the domestic and foreign market investigation and forecast data, integrating the following factors like mining area's resource conditions, process technology, construction conditions, environmental protection, economic benefits of project construction, etc., make the general and macro evaluation against the necessity of project construction, feasibility of construction conditions, and rationality of economic benefits; so that provide basis for whether performing the geology work in the prospecting phase, recommending the project, and preparing the project proposals.

### 7.4 Feasibility study

The feasibility study firstly needs carefully investigating, counting and analyzing the domestic and foreign ore resources, reserves, production and consumption; then analyze, study and predict the demand, product type, quality requirement, price and competitiveness on the domestic and foreign markets. In the work, it shall carefully analyze and study the resource (or material) conditions, fully consider the impact of geology, mining, mineral separation, environment, laws and government economic policies. Do the in-depth and meticulous investigation and study, analysis and calculation, and multi-program comparison in the following aspects including enterprise production scale, mining mode, exploring program, mineral-separation process flow, product scheme, selection of major equipment, water-and-electricity supply, overall arrangement of industrial square, and environmental protection, etc.; depend on and evaluate the current market price; then confirm the investment, production and operation cost, sales revenue, profits and cash inflows and outflows, etc. Their work depth shall meet the requirements for economic evaluation. The technical and economic data of the project shall meet the requirements of relevant

**8.1.3** Economic meaning: it is the results of feasibility evaluation. It can be divided into four kinds including economic, marginal economic, sub-marginal economic, and intrinsic economic ones.

**8.1.3.1** The economic: its quantity and quality shall be calculated as per the production index confirmed by that is in line with the market prices. It shall be explored under the current market conditions in the feasibility study and pre-feasibility study; it is technically feasible, economically rational, environmentally and other conditions allowable; namely, the average value of mining ore products each year can meet the requirements for return of investment. The enterprise's internal rate of return is greater than the industry benchmark rate of return.

**8.1.3.2** The marginal economic: during the feasibility study or pre-feasibility study periods, its exploration is uneconomic, but close to the profit and loss boundary; the enterprise's internal rate of return is greater than zero and less than industry benchmark rate of return; only under the following conditions can it become economic such as the technological, economic, environmental conditions are improved, or government gives other support.

**8.1.3.3** The sub-marginal economic: during the feasibility study or pre-feasibility study periods, the exploration is uneconomic or technically infeasible; the enterprise's internal rate of return is less than zero; it requires to substantially improve the ore product price or make technology progress, so that the cost can be reduced, then it can become economic.

**8.1.3.4** The intrinsic economic: it only makes the corresponding investment opportunity evaluation through overview study rather than the pre-feasibility study or feasibility study. Due to many uncertainties, it is impossible to distinguish the economic, marginal economic or sub-marginal economic.

### 8.2 Resource/Reserve type

According to the three-dimensional elements of Economic meaning (E), Feasibility evaluation (F) and Geological reliability (G), the resource/reserve can be divided into three classes, namely, reserve, basic reserve and resource amount, as well as 16 types; each type is given 3-digit code according the sequence of EFG (see Appendix A).

#### 8.2.1 Classification of the measured mineral resource

The measured mineral resource can be divided into 9 types according to its feasibility study degree and economic meaning. The measured mineral resource serves as the major basis for the mine construction.

##### 8.2.1.1 Recoverable reserves (111)

It is the recoverable part of the measured economic basic reserves. It refers to perform

on the encrypted engineering section required in the prospecting phase; carefully encircle the orebody in the three-dimensional space; affirm the orebody continuity; carefully identify the deposit geological characteristics, ore quality and exploring technical conditions; there are test results of the ore processing technology; the feasibility study has been carried out, which includes the following factors study and corresponding modification such as exploration, economy, market, law, environment, society and government, etc.; it proves that the exploration at the calculation period is economic.

#### 8.2.1.2 Measured (Feasible) economic basic reserves (111b)

The difference with recoverable reserves (111) refers to that this type is expressed by the quantity without deducting the design and mining losses.

#### 8.2.1.3 Pre-recoverable reserves (121)

It is the recoverable part of the measured economic basic reserves. It refers to perform on the encrypted engineering section required in the prospecting phase; carefully encircle the orebody in the three-dimensional space; affirm the orebody continuity; carefully identify the deposit geological characteristics, ore quality and exploring technical conditions; there are test results of the corresponding ore processing technology; however, only the pre-feasibility study has been carried out, which indicates that the current exploration is economic.

#### 8.2.1.4 Measured (Pre-feasible) economic basic reserves (121b)

The difference with pre-recoverable reserves (121) refers to that this type is expressed by the quantity without deducting the design and mining losses.

#### 8.2.1.5 Measured (Feasible) marginal economic basic reserve (2M11)

It refers to perform on the section with exploration work degree meeting the requirements in the prospecting phase; carefully identify the deposit geological characteristics, ore quality, exploring technical conditions. The feasibility study results indicate that the exploration is uneconomic at the confirming period, but it is close to the profit and loss boundary; it can only become economic after the technical and economic conditions are improved.

#### 8.2.1.6 Measured (Pre-feasible) marginal economic basic reserves (2M21)

Its characteristics are basically the same as the marginal economic basic reserve (2M11); this type only performs the pre-feasibility study, which indicates that the exploration is uneconomic at the confirming period, however, it is close to the profit and loss boundary.

#### 8.2.1.7 Measured (Feasible) sub-marginal economic resources (2S11)

It refers to perform on the section with exploration work degree meeting the requirements in the prospecting phase; the geological reliability degree is measured; the feasibility study results indicate that the exploration is uneconomic at the confirming period; only after improving the ore product price and greatly reducing the cost, can it become economic.

#### 8.2.1.8 Measured (Pre-feasible) sub-marginal economic resources (2S21)

Its characteristics are basically the same as the sub-marginal economic resources (2S11); this type only performs the pre-feasibility study, which indicates that the exploration is uneconomic at the confirming period; only after improving the ore product price and greatly reducing the cost, can it become economic.

#### 8.2.1.9 Measured intrinsic economic resources (331)

It refers to perform on the section with exploration work degree meeting the requirements in prospecting phase; geological reliability degree is measured; it doesn't do the feasibility study or pre-feasibility study; its economic meaning is between the range of the economic and the sub-marginal economic.

### 8.2.2 Classification of the indicated mineral resources

The indicated mineral resources can be divided into 5 types according to its feasibility study degree and economic meaning. The indicated mineral resource can serve as the design basis for the mine construction.

#### 8.2.2.1 Pre-recoverable reserves (122)

It is the recoverable part of the indicated economic basic reserves; it refers to basically encircle the three-dimensional shape of the orebody on the section meeting the requirements of detailed survey work degree; can confirm the orebody continuity to a great extent; basically identify the deposit geological characteristics, ore quality, exploring technological conditions; provide test results of the ore processing technology; the pre-feasibility study results indicate the exploration is economic.

#### 8.2.2.2 Indicated economic basic reserves (122b)

Its distribution characteristics are the same as the pre-recoverable reserves (122); their difference lies in that this type is expressed by the quantity without deducting the design and mining losses.

#### 8.2.2.3 Indicated marginal economic basic reserves (2M22)

It refers to on the section reaching the detailed survey phase work degree, basically identify the deposit geological characteristics, ore quality, exploring technological conditions; basically, encircle the thee-dimensional shape of the orebody. The pre-feasibility study results indicate that the exploration is uneconomic at the confirming

### 9.2 General principles of resources/reserves estimation

**9.2.1** The resources/reserves shall be estimated as per the industrial indicators. Under the market economy conditions, the resource/reserve classification ratio can be confirmed as per the demands of the investors.

**9.2.2** The resource/reserve in the deposit shall be separately calculated as per the following factors like orebody resource/reserve type, block, ore type, grade; for the orebody with representative thickness of continuous 8m, if its grade is weighing up to the industrial grade, it can participate in the estimation; the estimation unit is ten thousand tons.

**9.2.3** When the humidity, karst rate and crack rate of the ore in the orebody is greater than 3%, then correct its resource/reserves.

**9.2.4** The peeling amount shall be estimated according to the subdivision of waste rock; the calculation unit is $m^3$.

**9.2.5** The work quality involving the resource/reserve estimation shall meet the requirements of relevant norms, rules and regulations.

**9.2.6** The resource/reserve estimation shall use the computer technology.

### 9.3 Confirming the requirements for resources/reserves estimation parameters

It generally includes the orebody encircled area, thickness, volume mass (weight), and the like calculation parameters; it shall be based on the actual measurement; the data are required to be true, accurate, representative. Estimate the inferred and predicated resources/reserves; if lacking of the actually-measured orebody volume mass (weight), the analogy method can be adopted.

### 9.4 Resources/Reserves estimation result table

Confirm the economic meaning according to the geological reliability degree and feasibility evaluation work results; classify and estimate the resource/reserve required by the exploration work, the resource/reserve estimation results shall be expressed in table.

## 10 Preparation of Exploration Geological Report

The exploration geological report shall be prepared as per the requirements of DZ/T 0033-2002 *Specifications for Compilation of Geological Report of Solid-Mineral Exploration/Mine-Closing*.

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