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Specifications for Kaolinite, Bentonite, Refractory-clay Mineral Exploration

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Specifications for Kaolinite, Bentonite, Refractory-clay Mineral Exploration

1 Application Scope

This Standard specifies the requirements for the exploration study level and control level, exploration work quality, classification of mineral resources/reserves and type conditions, estimation of mineral resources/reserves for kaolinite, bentonite and refractory-clay mineral exploration; it proposes the ore deposit exploration types and the reference exploration engineering intervals for analogic use.

This Standard applies to the exploration of kaolinite, bentonite and refractory-clay minerals and the estimation of mineral resources/reserves; it applies to the acceptance and appraisal of the geological reports of kaolinite, bentonite and refractory-clay mineral exploration; it may also work as the basis for the assessment and estimation of mineral resources/reserves in the activities including mining right transfer and mineral exploration, development, financing and listing.

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 enter into 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 12719-1991, *Exploration Specification of Hydrogeology and Engineering Geology in Mining Areas*

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

3 Purposes and Tasks of Exploration

The exploration work of kaolinite, bentonite and refractory-clay is divided into four states, namely reconnaissance, general exploration, detailed exploration and prospecting. The purposes and tasks of all stages are as follows:

- Reconnaissance: in accordance with the areal geological study results and through preliminary field inspections, tiny amounts of engineering verification, analogies and speculations of known deposits of similar geological characteristics,

to come up with the areas of great potential of minerals for general exploration, in order to provide basis for the general exploration work;

- General exploration: for the areas of great mineral potential for general exploration, using inspection, geological mapping, limited number of sampling projects, to approximately identify the geological and structural conditions of the areas for general exploration; to approximately master the morphology and occurrence of ore body and ore quality characteristics; to understand the technical conditions for mineral exploitation; to conduct analogical study of the processing-dressing properties of minerals; to come up with whether it is worthy of general exploration further or to circle out the ranges of the detailed exploration areas;
- Detailed exploration: for the detailed exploration areas circled out in the general exploration, using large-scale geological mapping and all kinds of exploration methods and means including systematic sampling denser than in the general exploration stage, to basically identify the geology, structure and morphology, occurrence and size of major ore body and ore quality; to basically ascertain the continuity of ore body; to basically identify the technical conditions for ore deposit mining; to conduct analogies or optional tests and laboratory process test study for the processing-dressing of ore; and to make an assessment whether there is an industrial value. If necessary, circle out the exploration ranges for the use in feasibility studies, drafting mining overall plans and compiling mining project proposals. For the mining areas which are directly developed and utilized, the degree of the processing-dressing property test shall meet the requirements for the mine construction and design;
- Prospecting: for the ore bodies of a known industrial value or the prospecting areas circled out in the detailed exploration, by increasing all kinds of sampling projects whose interval shall ensure the continuity of ore bodies (strata), to identify in detail the geological characteristics of ore body; to ascertain the morphology, occurrence, size and spatial position of ore body and ore quality characteristics; identify in detail the technical conditions for mining of ore body; to conduct the laboratory process test or laboratory scale-up continuous test for the processing-dressing properties of minerals and to conduct the pilot plant test if necessary, in order to provide basis for feasibility studies and mine construction and design.

4 Level of Exploration Study

4.1 Level of geological study

4.1.1 Reconnaissance stage

Collect and study the data of regional geology and minerals; study the mineral occurrences and the distribution ranges and metallogenic prospects of mineralized points; conduct preliminary field work and prediction based on the analogies of the ore deposits of similar geological characteristics, in order to come up with the mineral potential areas for general exploration.

thickness, distribution, karsts, fractures and development degree and aquosity of structurally fractured zones. Study the groundwater recharges; the relationship between runoffs, drainage conditions and surface water bodies; the influence on the mining of deposits. Investigate the distribution of old mines and standing water. Ascertain the hydrogeological types. Calculate the water inflow of the first mining level (or the middle section above the construction water level) and estimate the water inflow quantity of the next mining level. Make assessment for deposit dewatering, drainage and mine water supply.

4.4.3.2 Engineering geological study

Study the rock types of deposits; classify the engineering geological formation complexes of rock (soil) mass; identify the nature, occurrence and distribution of engineering geological formation complexes disadvantageous to deposit mining, texture of rock masses and rock mass quality. Study the physical and mechanical properties of soil strata, ore strata and rock strata; measure the parameters of relevant physical and mechanical properties of ore bodies and wall rocks of roof and floor, such as volume mass (body weight), lumpiness, humidity, coefficient of volumetric expansion, natural angle of repose, compressive strength and shear strength. Study the influence of faults, joints, fractures, karts, weathering and soft strata on the stability of rock masses; and ascertain the engineering geological types. Assess the stability of the side slopes of open pits and the stability of roadway wall rocks.

4.4.3.3 Environmental geological study

Collect the earthquake data within areas; assess the stability of mining areas. For those radioactive mining areas, make comments on the radioactive environment quality. During the mining process of deposits, with regard to the possible damages to and influences on the geological environment of mining areas, such as rockfalls, collapses, landslides, debris flows, karsts, subsidences, surface subsidence and water body pollution, make predictions and comments and give suggestions for prevention and control. When ore bodies and coal strata coexist, collect the spontaneous combustion data of gas, coal dust and coal.

4.5 Comprehensive prospecting and comprehensive assessment

4.5.1 General exploration stage

Approximately know about the species, scales, material compositions, occurrence states, distributions, industrial values and utilization possibilities of associated and symbiotic minerals.

4.5.2 Detailed exploration stage

Use the existing prospecting projects to identify and study basically the species, scales, material compositions, occurrence states, distribution regularities of associated and symbiotic minerals; conduct comprehensive prospecting and comprehensive

of ore bodies (strata) on their two sides, intensify engineering to control the zoning of attributes and conduct determination of all single samples.

For refractory-clay, the general determination items include the content, loss on ignition and refractoriness of Al_2O_3 , TiO_2 and Fe_2O_3 . When the content of TiO_2 is low, it may be omitted in the basic analytical items. The determination of the CaO content needs to be added for high-aluminium clay; and when the Fe_2O_3 content exceeds the index requirement, the SiO_2 analysis needs to be added. For soft and semi-soft clay, choose the representative samples for plasticity determination.

6.4.3.2 Combinatory analysis

Kaolinite: use the industrial indexes of raw ores for assessment; use the accessory samples of the basic analysis as the samples; and conduct weighted combination in accordance with the sampling length: when using the industrial indexes of washed concentrates to circle mines, use the accessory samples from washing concentrates; also combine an appropriate amount of tailings sample; and combined in accordance with granulometric class (or not in accordance with granulometric class). The combinatory analysis items usually include 7 items, i.e. SiO_2 , MgO , CaO , Na_2O , K_2O , TSO_3 (total-sulfur gangue) and loss on ignition.

Determination of colloid index and swelling capacity of bentonite: reflect the basic physical properties of ores; and use the combinatory samples. For the ore bodies (strata) which cannot be separated in the recovery in accordance with the content grades of montmorillonite, take combinatory samples separately in accordance with the mean content of attribute montmorillonite; and for the ore bodies (strata) which can be separated in accordance with the content grade of montmorillonite, take combinatory samples separately in accordance with the attributes and grades. The quantity of combinatory samples shall not be less than 5 each. The combination method of the samples is to use the weighed length of single engineering or adjacent engineering on the neighboring section. If the colloid index of sodium bentonite is greater than 100 ml/15 g, use a 500 ml measuring cylinder for measurement or add the measurement of bentonite value. For aluminium (hydrogen) bentonite, the determination of colloid index and swelling capacity may be omitted.

The combinatory analysis of refractory-clay generally includes SiO_2 , CaO , MgO , SO_3 , Na_2O , K_2O and loss on ignition. When the content of some harmful impurity is high in the combinatory analysis of the impurity shall be added in the basic analysis. The combinatory samples are chosen from the accessory samples of the basic analysis: not less than 10 samples for major grades of ore deposits; and not less than 5 samples for secondary grades.

6.4.3.3 Chemical multi-element analysis and semi-quantitative spectrometric analysis

The chemical multi-element analysis shall be carried out for raw ores and washed concentrates of kaolinite, and the chemical multi-element analysis of tailings. The

demand states of mineral resources at home and abroad, analyze the geological data of general exploration or detailed exploration and prospecting; compare with the ore deposits already known; and make technical-economic assessment for ore deposits in consideration of the natural economic conditions, environmental protection and other aspects of the mining areas, using the technical-economic indexes or scale-up indexes of similar enterprises in China. Therefore, the basis is provided for the determination whether there is an investment opportunity for ore deposit development, whether the work of detailed exploration stage will be carried out, and drawing up long-term planning or engineering construction planning.

7.2 Pre-feasibility study

The pre-feasibility study or feasibility study and assessment need to be carried out in the stages of detailed exploration and prospecting. The pre-feasibility study needs to give a preliminary prediction in a relatively systematic way of the market demands, product species, quality requirements and price trends at home and abroad. In accordance with the scale of ore deposits, the geological characteristics of ore deposits and the geographic and geomorphic conditions, make preliminary study and propose the project construction scales, product species, overall contours and technical principles and plans for mining areas' construction, by using the practical experiences of similar enterprises. Referring to similar enterprises, choose the technical-economic indexes suitable for the assessment of the current market prices, make preliminary proposals of total investments in construction, main quantities, main equipment, production costs and so on; carry out preliminary economic analysis; circle and estimate different types of mineral resources/reserves.

Based on the market research at home and abroad and predictive data, summarize all factors including mining areas' resources, technique, construction conditions, environmental protection, economic benefits of project construction and so on; make assessment on the whole for the necessity of project construction, feasibility of construction conditions and rationality of economic benefits; and provide basis for the determination whether the geological work in the prospecting stage will be carried out, recommending projects and compiling project proposals.

7.3 Feasibility study

The feasibility study first needs to provide careful investigation, statistics and analysis of resource, reserves, production and consumption of a mineral at home and abroad; and it shall provide analysis, research and prediction of demands, product species, quality requirements, prices and competitiveness of the markets at home and abroad. The resource (or raw material) conditions shall be studied carefully in practice, giving full consideration to the influences of geology, engineering, environment, laws and economic policies of the government. Carry out investigation, analytical calculation and multi-scheme comparison in a meticulous and deepgoing way, with regard to enterprise production scale, mining method, development scheme, dressing process, product program, selection of major equipment, supply of water and power, overall layout, environmental protection, etc.; based on the market prices at the time of

in the intensified engineering sections achieving the prospecting stage, including circling ore bodies in detail in the three-dimensional space; ascertaining the continuity of ore bodies; identifying in detail the geological characteristics of ore deposits and the quality and technical conditions for mining of ores; and providing the test results of relevant ore processing techniques. But only pre-feasibility study is carried out to indicate the mining at that time is economic.

8.2.1.3 Probable extractable reserve (122)

The extractable part of controlled economic basic reserve. It refers to the procedures in the sections achieving the detailed exploration work level requirements, including basically circling the three-dimensional morphologies of ore bodies; being capable of securely ascertaining the continuity of ore bodies; basically identifying the geological characteristics of ore deposits and the quality and technical conditions for mining of ores; providing the test results of relevant ore processing techniques; the results of pre-feasibility study indicating the mining is economic.

8.2.2 Basic reserves (six categories)

8.2.2.1 Proved (feasibility study) economic basic reserve (111b)

Its difference from extractable reserve (111) is in that the category is to describe using the quantities not deducted by losses on design and mining.

8.2.2.2 Proved (feasibility study) economic basic reserve (121b)

Its difference from probable extractable reserve (121) is in that the category is to describe using the quantities not deducted by losses on design and mining.

8.2.2.3 Controlled economic basic reserve (122b)

It has the same distribution characteristics as probable extractable reserve (122); and its difference is in that the category is to describe using the quantities not deducted by losses on design and mining.

8.2.2.4 Proved (feasibility study) marginal economic basic reserve (2M11)

It refers to, in the sections where the exploration work level has met the requirements for the prospecting stage, detailed identification of the geological characteristics of ore deposits and the quality and technical conditions for mining of ores. The results of feasibility study indicates the mining is not economic at the time of determination, but close to the boundaries of profits and losses; and that it can only become economic when the technical-economic conditions are improved.

8.2.2.5 Proved (pre-feasibility study) marginal economic basic reserve (2M21)

Basically identical to the distribution characteristics of basic reserve (2M11); only pre-feasibility study is carried out for this category, indicating the mining is not economic at the time of determination, but close to the boundaries of profits and losses.

8.2.2.6 Controlled marginal economic basic reserve (2M22)

It refers to the procedures in the sections achieving the detailed exploration stage, including basically identifying the geological characteristics of ore deposits and the quality and technical conditions for mining of ores; basically circling the three-dimensional morphologies of ore bodies; and the results of the pre-feasibility study indicating the mining is not economic at the time of determination, but close to the boundaries of profits and losses. It may become economic when the technical-economic conditions are improved in the future.

8.2.3 Resources (seven categories)

8.2.3.1 Proved (feasibility study) sub-marginal economic resource (2S11)

It refers to, in the sections where the exploration work level has met the requirements for the prospecting stage, that the geological assurance is proved; that the results of feasibility study indicates the mining is not economic at the time of determination; and that it can only become economic by increasing substantially the product prices or lowering substantially the costs.

8.2.3.2 Proved (pre-feasibility study) sub-marginal economic resource (2S21)

Basically identical to the distribution characteristics of economic resource quantity (2S11); only pre-feasibility study is carried out for this category, indicating the mining is not economic at the time of determination, but close to the boundaries of profits and losses.

8.2.3.3 Controlled marginal economic basic reserve (2S22)

It refers to, in the sections where the exploration work level has met the requirements for the detailed exploration stage, that the geological assurance is controlled; that the results of feasibility study indicates the mining is not economic at the time of determination; and that it can only become economic by increasing substantially the product prices or lowering substantially the costs.

8.2.3.4 Proved intrinsic economic resource (331)

It refers to, in the sections where the exploration work level has met the requirements for the prospecting stage, that the geological assurance is proved, but feasibility study or pre-feasibility study has not been carried out; and that only geological study is carried out, indicating its economic significance is within the scope of economic ~ sub-marginal economic.

8.2.3.5 Controlled intrinsic economic resource (332)

It refers to, in the sections where the exploration work level has met the requirements for the detailed exploration stage, that the geological assurance is controlled; that only geological study is carried out for feasibility assessment; and that the economic significance is within the scope of economic ~ marginal economic.

B.1.1.3 Thickness stability degrees

Stable: the thickness variation coefficient $\leq 40\%$; and the thickness variation is regular.

Relatively stable: the thickness variation coefficient $40\% \sim 70\%$; and the thickness variation is relatively regular.

Unstable: the thickness variation coefficient $> 70\%$; and the thickness variation regularity is not obvious.

B.1.1.4 Internal texture complexity of ore bodies (strata)

Simple: the ore quality is stable or the variation is regular with the linear or plane stone rate $\leq 10\%$. The variation coefficient of montmorillonite mass fraction of bentonite ore deposits $< 20\%$.

Medium: the ore quality is relatively stable with the linear or plane stone rate $10\% \sim 20\%$. The variation coefficient of montmorillonite mass fraction of bentonite ore deposits $20\% \sim 30\%$.

Complex: the ore quality is unstable with the linear or plane stone rate $> 20\%$. The variation coefficient of montmorillonite mass fraction of bentonite ore deposits $> 30\%$.

B.1.1.5 Structural complexities

Simple: ore bodies (strata) show monocline or simple open anticline; and there is no large faulted structures or vein rocks, having small influences on the morphology of ore bodies.

Medium: ore bodies (strata) have secondary folds or local compact folds; and there are a few large faults and vein cuts, having certain influences on the morphology of ore bodies (strata).

Complex: faults, folds or vein rock develop, having great influences on ore bodies (strata).

B.1.2 Exploration types

Exploration type I: large extending scale of ore bodies (strata); regular morphology; stable thickness; and simple internal textures and geological structures. For example: Guangdong Maoming kaolinite ore deposit; Guangxi Ningming bentonite ore deposit; and Shandong Xiaokoushan refractory-clay ore deposit.

Exploration type II: medium $\sim$ large extending scale of ore bodies (strata); relatively regular morphology; stable thickness; and simple to relatively simple internal textures and geological characteristics. For example: kaolinite ore deposits of Hunan Jiepai and Jiangsu Guanshan; bentonite ore deposits of Liaoning Heishan, Zhejiang Pingshan and Fujian Wuping; and refractory-clay ore deposits of Shanxi Taihushi, Jilin Shuiquli and Xinjiang Qianshuihe.

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