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Construction of 3D Metallogenic Model of Deep Metal Minerals Based on Geophysical Exploration

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Abstract: *In the process of rapid economic development, the demand for mineral resources is increasing day by day. Mineral resources are important basic resources in China's social development, and play a very important role in promoting China's industrial production and economic development. At present, the traditional mining methods of mineral resources can't meet the current demand, so in order to alleviate the shortage of resources, it is necessary to explore and mine deep mineral resources. Based on this, this paper takes deposit geology, geographic information science and computer science as theoretical basis, comprehensively applies computational geometry method, computer graphics and image processing method, geological statistics method, etc. to study deep metal minerals based on geophysical exploration, and constructs a 3D metallogenic model. In this paper, based on the establishment of MSAccess database, the 3D spatial model of the deposit is established by using the borehole data based on ArcScene. With the analysis system developed based on ArcGISEngine, it carries out graphic management, data management, 3D display, 3D spatial analysis and geostatistical analysis. This provides a reliable reference for the future wide application of geophysical methods, and provides another idea and method reference for the establishment of 3D models.*

Keywords: *Geophysical exploration; Metal minerals; 3D modeling*

1. Introduction

Mineral resources are non-renewable resources. With the increasing demand of mineral resources at home and abroad and the gradual decline of global mineral resources, the protective development of mineral resources has become the focus of attention of relevant departments engaged in mining, geology and energy around the world [1]. With the development of economy, people's demand for mineral resources is constantly increasing, and the depth of developed minerals is also increasing [2]. At present, most of the front metal mineral resources in China, near-surface and open-air mineral resources have been basically detected by explorers, and the mining of shallow metal mineral resources on the surface is also being carried out smoothly [3]. At the same time of developing surface mines, people have improved the intensity of resource development, and have also explored deep metal mine resources [4]. However, deep metal mineral exploration has always been a difficult point in prospecting, and at present, prospecting is developing at a deeper level, which is the key to solving the problem of resource shortage. Therefore, it is necessary to attach great importance to geophysical methods to solve the technical problems in deep prospecting.

Metal minerals are important minerals formed by deep-seated minerals in the earth's crust through energy conversion. Many facts prove that the point of view is that deep-seated exploration in the earth's crust is now the key development trend of metal mineral processing, and it is also the key point of the scarcity of metal resources in today's society [5]. It will be difficult to find ore in the deep part, which refers to the second depth space within the depth range of 500km~2km from the surface[6]. This technology can show obvious advantages and important role in deep prospecting, and it can help China's mineral resources field to explore more deep metal mineral resources, thus promoting the development of China's resource industry [7]. At present, the collection of deep metal minerals has become a trend, and the exploration of deep metal minerals through geophysical exploration methods is highly operable [8]. In geophysical exploration, a mapping relation can be abstracted from the teaching point of view, that is, it is mapped from the model space to the data space that can be perceived, and it is mapped to the model space in reverse. This paper discusses the role of geophysical exploration technology in the exploration of deep metal mineral resources, and constructs a 3D metallogenic model.

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2. Causes of the formation of deep metal mineral resources

Minerals generally refer to all natural mineral resources that exist in the earth's crust, or are buried underground or exposed on the surface, and can be used by human beings. It is the basic material basis and one of the important means of production for the survival and development of human society. Minerals are non-renewable [9]. The metal deposits that can be found in the shallow underground, including large and super-large metal deposits and polymetallic deposits, are all produced by the alternation of matter or energy in the development process inside the earth, instead of being produced and accumulated on the surface. During the formation process, a large number of metal elements are exchanged from the deep crust to the shallow surface through some processes. These transfer processes mainly include the movement and transformation of thermal materials, the upwelling of thermal materials into the crust and the alteration and accumulation of surrounding rocks. Due to the migration and accumulation of mineral elements, large and super-large metal deposits and polymetallic deposits will be affected by the continuous exchange of deep matter or energy, in which the hot matter will be altered and metasomatized with the surrounding rock of the medium during the continuous migration or upwelling. At present, it is necessary to solve the problem of deep mineral resources survey through more professional and convenient technical means [10].

3. The value of geophysical exploration in deep metal mineral resources exploration

3.1. Geophysical exploration can solve problems that cannot be solved by ultra-deep drilling

Geophysical exploration can solve the problems that ultra-deep drilling can't solve. Traditional geological exploration technology can't detect and analyze the physical properties and spatial distribution in the deep crust, so we can only know the mineral structure and storage information in the deep crust through advanced drilling technology. However, advanced drilling technology can only detect the vicinity of the drilling position, which has great limitations for some mineral resources distribution areas with complex geological structures. In addition, the use cost of drilling technology is very high, so it is impossible to carry out ultrasonic drilling according to the local topography distribution and site conditions in the actual detection process. This requires natural earthquakes and magnetotellurics to detect concentration. Geophysical methods can be used to detect deep metal minerals, and then ore analysis can be carried out for specific evaluation. In the aspect of deep geological mapping and optimization of deep prospecting target areas, the former can make a specific analysis of metallogenic causes and related factors in a certain area, and find out the metallogenic regularity in detail, so that there will be more basis when selecting deep prospecting target areas. You can explore the structure of the upper part of the sedimentary layer, and get some knowledge of the basement and the degree of weathering. Geophysical exploration technology plays a key role in the prospecting and mining of deep metal mineral resources, which shows that geophysical exploration technology is a feasible way. Taking the electromagnetic exploration conducted in a certain area as an example, in addition to the basic structure of the crust, the exploration depth is within the range of 0km ~ 50km, the specific source and migration direction of the main ore-forming materials in the mining area are also explored, and the corresponding explanation is given for the formation reason of the mining area.

3.2. The role of geophysical exploration technology in the exploration of deep metal mineral resources

Geological prospecting is a relatively complicated project, which has certain risks and takes a long time. The formation of shallow metal mineral resources has a great relationship with the evolution of the earth, and it is related to the deep dynamic process and development knowledge such as crustal movement, geological structure, material form, spatial distribution, etc. Therefore, the traditional prospecting methods can hardly meet this demand. Usually, large concentration detection methods, such as natural earthquakes and magnetotellurics, are needed. Geophysical methods can help people establish the thickness of geological structures and underground structures, and explore geological fluctuations. In order to better explore the fluctuation of basement geology, the existing science and technology are used to carry out exploration, analyze the fluctuation of basement geology according to parameter information, and establish the shape and distribution of various physical strata. Geophysical exploration technology refers to the method of deep geological filling, deep scanning and determination of metallogenic regularity and background in a certain geographical area, and locking a specific area

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with mineral resources. This method can mainly help geological prospecting personnel to determine the thickness of differentiation layer and the specific structure of sedimentary cover in a certain depth range, and can also detect and study the changing law of basement undulation in mineral areas.

Controlled-source audio magnetotelluric method is a common detection method in deep metal mineral resources exploration, which is mainly based on magnetotelluric emission. When deep exploration is carried out, the geophysical way of terrain can be used to find out the extracted position more directly by using the exploration of various physical rocks and high-precision analysis. The effect of geophysical exploration is very obvious. In the process of exploration, it is necessary to ensure that there are electrical differences between the exploration geology and rocks, so as to distinguish the mineral resources factors, and minimize the interference in the exploration to ensure the accuracy of the detection results. In addition, by establishing a deep geophysical inversion model, we can further determine the actual geological structure of the internal geographical environment in areas containing deep metal deposits. Because many metal deposits were formed by magma after a long period of deposition, they are easily affected by deep faults. Take metal mineral resources as an example. Because this mineral resource is special and has a certain relationship with magma, we can make detailed analysis by magma movement to determine the specific location. Geophysical exploration method explores the ups and downs of the base through the removal of weathered layer and the establishment of sedimentary cover mechanism. Because granite, basic-ultrabasic intrusive rocks and metal deposits are directly or indirectly related to their production and distribution, it is necessary to establish the main forms of rocks with various physical attributes to establish the ore-hosting level, and to use geophysical methods to carry out deep lithology mapping.

4. Construction of 3D metallogenic model

3D modeling technology can integrate information from various exploration methods and express it dynamically with intuitive 3D graphics. It provides a convenient analysis tool for dealing with these massive, complex, especially deep geological information, and fully combines the image thinking and logical thinking of geologists. The 3D metallogenic model mainly serves the establishment of digital mines, focusing on how to improve the exploration efficiency, production efficiency and management efficiency of mines, and improve the technical level of mining. 3D modeling is not only for mapping, but more importantly, through the establishment and simulation of the model, we can have a clearer understanding of the spatial distribution of ore bodies and maximize the exploration results. Firstly, this paper collects 3D spatial coordinate data of ore body contour line from digital mine geological profile. The profile data can be obtained by interpreting the original borehole data, or it can be derived from the existing profile map. Secondly, taking the collected contour lines of ore bodies as basic data, according to the spatial data model of ore bodies, a series of contour lines are used to construct triangulation network to form the surface model of ore bodies. Then smooth the surface model of the established ore body to obtain better display effect. Here, the influence of geological structures such as faults and folds on modeling is not considered in this paper.

Table 1: The fourth layer drilling data table

ID	X	Y	D3 (m)
11	88.9073	43.3282	1957.42
12	88.9062	43.3265	1979.10
13	88.9052	43.3254	1978.60
14	88.9059	43.3263	1918.89
21	88.9049	43.3278	1932.43
31	88.9088	43.3276	1890.91
32	88.9089	43.3255	1890.90
33	88.9096	43.3241	1833.90
42	88.9021	43.3279	1823.89
43	88.9011	43.3258	1833.91
51	88.9126	43.3269	1833.90
52	88.9115	43.3252	1795.57
53	88.9105	43.3235	1828.91
54	88.9098	43.3230	1828.90
61	88.9001	43.3291	1967.15
71	88.9148	43.3263	1770.39
72	88.9130	43.3239	1770.38

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Data collection includes the collection and collation of existing data and existing data, and digitization of data that can be digitized. Because of its intuitive, accurate and detailed characteristics, drilling data is of vital significance in 3D modeling. The data collection in this paper includes drilling catalog, trench catalog, roadway catalog, etc. For the data made by MapGIS software, it is converted into plain code format, so as to have better compatibility when importing 3DMine. The drilling data in the same stratum are stored in a drilling data table, thus obtaining four drilling data tables. As shown in Table 1.

Ground plane generated by interpolation of drilling point data. The borehole data in this paper has spatial correlation and is suitable for kriging interpolation method. Therefore, in this study, kriging interpolation method is used to generate the ground plane. For a specific modeling area, there may be a large number of boreholes, and the information provided by these boreholes includes the location of each borehole, the type of boreholes, and the stratification information of strata. Although these information are numerous, they are relatively regular and can be stored in the database to form a database of borehole attributes in a specific area for repeated use. Geological database is an effective data management tool, which can easily retrieve and manage data. To create a database with 3DMine, first of all, it is necessary to establish positioning table, inclinometer table, lithology table and laboratory analysis table respectively according to geological data. The position and trajectory of the borehole in 3D space are determined by positioning table and inclinometer. Lithology table and laboratory analysis table are used for later modeling and resource reserve estimation. Spatial analysis is based on geospatial database, and its application means include various geometric logical operations, mathematical statistical analysis, algebraic operations and other mathematical means. The ultimate goal is to solve practical problems related to geospatial information, extract and transmit geospatial information, so as to achieve the purpose of assisting decision-making. The modeling flow chart is shown in Figure 1.

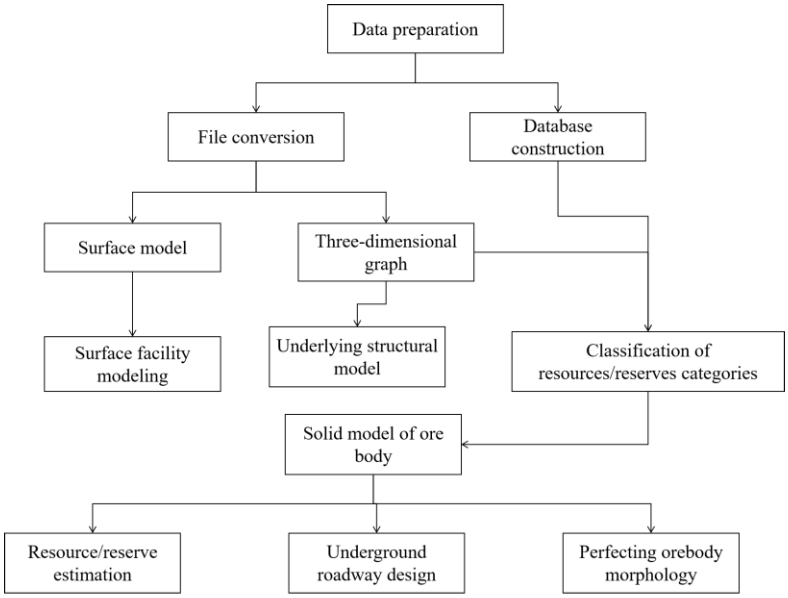

Figure 1: Modeling flow chart

In this paper, the total number of strata in the study area is determined by the maximum number of rock layers encountered in drilling, and those with the same lithology and similar positions in the vertical direction are regarded as one layer; Then, the sequence of strata is determined according to the up-and-down relationship between layers, that is, according to the relationship of vertical Z coordinates of rock strata encountered in drilling, and according to the up-and-down relationship of pressure and pressure between layers. As a result, four strata are divided. In order to improve the speed of real-time image scaling, the reduced image is generally stored on the disk in advance, so there is no need to resample and read data in a large range when it is displayed, thus saving a lot of time. This is the commonly used image pyramid technology, and this paper adopts the commonly used pyramid design method. The grade model is based on the ore body model. The principle is to establish a block model that can contain the whole ore body, and the block divides the ore body by many areas. Generally, 1/4 to 1/8 of the exploration grid is used to determine the block segmentation size. For the irregular ore body edges, the sub-grade size is used to segment the ore body, that is, 1/8 to 1/16. After the grade and weight data of the block are available, the resource reserves of the ore body can be directly estimated

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by software.

5. Conclusions

At present, China is in the development stage in the process of mining and resource utilization. As the demand for mineral resources in China is constantly increasing, and the current reserves of mineral resources can no longer meet the demand of the market, mineral exploration is extremely urgent. At present, the collection of metal mineral resources in China is mainly on the surface. With the increasing demand for minerals, the collection of deep metal minerals has become a trend. Geophysical exploration technology can survey the formation reasons of geological information and the distribution law of rock mass in deep mineral resources, and the survey results have a good application effect in actual case analysis. Although prospecting in deep crust has a very broad development prospect, we need to realize that traditional geological prospecting techniques and shallow prospecting methods have long been unable to meet the requirements of economic and social development for mineral resources. Therefore, it is the main development trend of metal beneficiation to search for underground deep metal deposits through geophysical exploration technology. In addition, in this paper, the 3D model of the deposit is established based on the borehole data, and the horizon is generated based on the borehole data interpolation in AreScene, and then the inner boundary is extracted for TIN interpolation to establish the 3D stratum model. At the same time, through the analysis of mineral data, this paper establishes the preliminary model of ore body and the ore body to be explored in the next step, and estimates the resources of the existing ore body model. Generally speaking, the research results of this paper have laid a good foundation for the research of dynamic calculation and management of reserves in metal mines.

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