International Core Journal of Engineering Volume 9 Issue 4, 2023
ISSN: 2414-1895 DOI: 10.6919/ICJE.202304_9(4).0047

Research on Digital Mineral Exploration and Prospecting Technology Based on 3D Deposit Modeling Technology

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Abstract

In China, mineral exploration is very important, and in order to improve the efficiency of digital mineral exploration, it is necessary to use related technologies. A large number of practical results show that 3D deposit modeling technology has a great application role in digital mineral exploration. In order to make up for the shortcomings of the existing digital deposit modeling technology in geological and mineral exploration and application, This paper summarizes and puts forward a set of ore deposit modeling process and overall technical solution for geological and mineral exploration business processing from five aspects: the establishment and standardization of original exploration data, the automatic delineation of multi-index single-project ore bodies, the connection and extrapolation of profile ore bodies based on semantic recognition, the modeling of ore body surface and grade, the construction of ore body surface model based on profile ore body wireframe model and the establishment of ore body spatial attribute model based on TIN+ Octree data structure and geostatistics theory, which improves the research accuracy of geological and mineral exploration and provides reliable data model for further mining. Through studying the current situation and methods of prospecting and exploration, the prospecting and exploration information is analyzed and classified from the perspective of database management and analysis, and the prospecting and exploration information database is established according to the database design principles and naming criteria.

Keywords

3D Deposit Modeling Technology; Digital Mineral Exploration; Prospecting Technology.

1. Introduction

With the increasing difficulty of global mineral exploration, using new technologies and methods to improve the discovery rate of concealed, deep and difficult to identify minerals is one of the main research topics in mineral exploration at present [1]. Applying modern spatial information theory, apply 3D deposit modeling technology to geological and mineral exploration research, establish 3D spatial and attribute models of deposits in the exploration area, meet the business requirements of comprehensive processing of exploration data, provide digital and visual analysis means for mine geological research, deposit prediction, ore body resource reserve estimation, and later mine mining design, and improve the accuracy of mineral exploration geological research and the comprehensive utilization efficiency of exploration results, It has important research significance [2]. The status of coal, which accounts for 70% of the primary energy structure, will not decline in a certain period in the future, so the healthy and stable development of the coal industry is related to the lifeline of the national economy. The resource recovery rate is low, the per capita recoverable reserves are small, the consumption is large, and the way of resource development and utilization is difficult to support

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the long-term economic and social development. China's coal mining technology and mechanization level are not advanced enough [3]. The management ability of leaders and the uneven level of employees lead to poor working environment, and mines with low production efficiency still account for a large proportion in China. Strive to greatly improve the basic theoretical level of deep mineralization and reservoir formation research and evaluation and prediction of deep-seated resources, overcome the major key technologies of deep-seated resources exploration, and improve the exploration and mining capabilities of deep-seated mineral resources and energy. At the same time, in recent ten years, with the improvement of computer software and hardware performance, 3D visualization technology has made great progress [4].

Through the integrated analysis of comprehensive data such as geology, geophysics, geochemistry, and remote sensing, and with the help of modern and mature gravity and magnetic inversion technology and three-dimensional visualization technology, a three-dimensional visualization geological model is constructed, the spatial distribution relationship between mineralization and main ore-controlling geological bodies is systematically analyzed, and the deep ore-controlling factors are understood and screened, improving the prediction level of deep ore prospecting [5]. The current goal of mineral exploration is to discover new rich minerals, deep minerals and special minerals. The implementation of these tasks is relatively difficult. To achieve these goals, we must use high-tech technology. A large number of practical results show that it is very feasible to use 3D deposit modeling technology in digital mineral exploration, which not only meets the relevant requirements of current mineral exploration, but also improves the efficiency of deposit prediction and ore body estimation, and promotes the development of mineral exploration informatization and digitalization [6]. There are three main purposes for the development of the information management system for prospecting and exploration of metal deposits: first, to provide an information platform for the public to fully understand the mining area; The second is to serve the prospecting and exploration departments, provide reliable and accurate metallogenic prediction information, and provide theoretical basis for finding new mining areas. The third is to provide data support for the management and decision-making of government departments [7].

Based on the three-dimensional geological model, this paper establishes a comprehensive prospecting model in the study area by anatomizing the representative veins and altered geological bodies of Kekesala typical deposit and combining with other comprehensive information collected by typical deposits. Based on the comprehensive ore-prospecting model, the compound ore-prospecting information of the study area, such as location, object, chemistry and distance, is extracted, and the three-dimensional space is quantified and calculated to realize the location and evaluation of deep mineral resources.

2. Construction of Digital Mineral Exploration and Prospecting Technology

2.1 Mining Area and Deposit Geology

Prospecting and exploration are a humanistic activity, a systematic investigation, investigation and search for the discovery of mineral deposits, a process of identifying and continuously narrowing the mineral deposits with economic value from a large area, and a scientific research and productive work with dual nature of scientific practice and production practice, with different meanings and contents in different periods and regions [8]. In general, ore prospecting is to sample, experiment and analyze the area under study according to certain metallogenic theories, means and methods, so as to determine whether there is ore in the area under study, and then use what means or methods to explore the location of the ore body, the type of ore, the reserves of ore, the material composition, and what methods can be used for mining, so as to facilitate the planning, mining Construction provides necessary data and information [9]. Commercial mineral exploration should respect the laws of the market, take profit as the purpose, and belong to a kind of venture capital. In line with the principle of "who invests, who benefits", its results are exclusive and competitive. China now takes the market

ISSN: 2414-1895 DOI: 10.6919/ICJE.202304_9(4).0047

economy as the leading factor, and commercial mineral exploration has gradually become the main body of mineral exploration work, which is an important part of the mining industry [10].

The mine geological database has the functions of dynamic controllability and change verification. The mine geological database can intuitively display the geological information such as borehole trajectory, depth, geological lithology and basic characteristics of ore bodies through the image display function, and can divide different information into sections with different colors or the same data information and give them different colors to display, so that the geological information can be displayed in different colors, which is more intuitive and clear. In short, the information collected and entered into the mine database can be displayed in different colors by combining words with graphics, and can be queried, edited, updated and analyzed. The purpose of establishing a digital deposit model for mineral geological exploration is to realize the comprehensive expression of mineral resources reserve estimation and mineral resources investigation information, as shown in Figure 1.

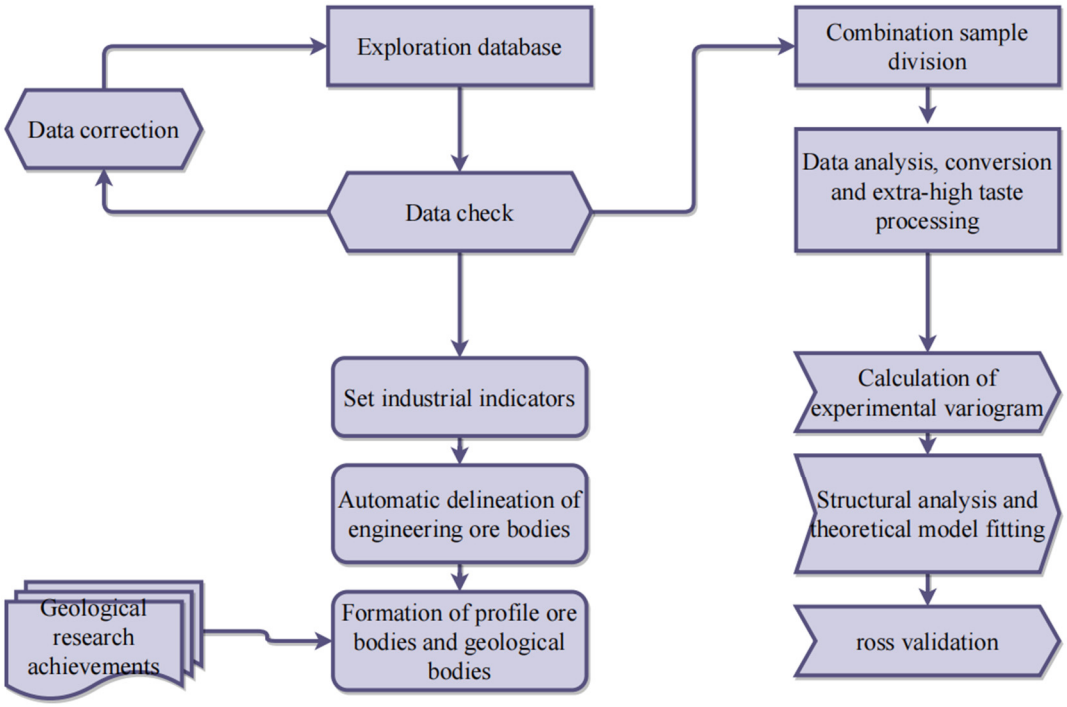

Figure 1. Basic process of digital deposit modeling

The whole process is mainly composed of four parts: (1) establish the exploration database of the mining area or exploration area, and complete the inspection and correction of the data; (2) Delineation of engineering ore body and construction of boundary line of exploration profile ore body and geological body; (3) The three-dimensional surface model of the ore body is constructed, and the spatial attribute model of the ore body is constructed according to the surface model; (4) Based on the spatial interpolation theory of geostatistics, the ore body attribute model is assigned.

2.2 Classification of Prospecting and Exploration Information

Prospecting and exploration information data generally includes geological, mining, survey, management and other data. Each data has a certain format and specification requirements. In the system, these data must meet the specifications and standards of the entire system. Therefore, it is necessary to study the system data source. In terms of the fields involved in prospecting and exploration information, it includes geological, remote sensing, geophysical, geochemical, engineering and other data; In the form of data, prospecting and exploration information includes graphics, images, words or figures, tables and video data. The mineral resources economic zone is a planned and determined area with the advantages of developing mining industry based on such factors

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as the endowment and supporting degree of mineral resources, development and utilization status, mining economic development status and industrial policy. The purpose of promoting the economic zone of mineral resources is to promote the exploration, development and utilization of superior mineral resources, extend the industrial chain, promote the development of subsequent smelting and processing industries, and guide the rational layout of heavy chemical industry, raw materials and other bases in China based on resources. The types of data import are update, insert and insert and update. Insert is selected when the new database is first imported, and update or insert and update can be selected when the original data needs to be inserted or overwritten. Surpac also provides powerful tools to verify the correctness of the data, including the maximum depth error, sample overlap, calculation results, etc. If there is no error, a blank file will be generated. If there is an error, an error warning will be generated, and the results will be saved in the audit report file, so that the wrong data can be modified according to the detailed report generated by the reporting error until there is no error. In the process of revision, some errors exist in a series or the same error. As long as one of them is found, a class of errors can be solved. After repeated corrections and audits, the geological database of Hedong Mine was finally established.

For the automatic delineation of engineering ore bodies, some scholars have done relevant research, but it is basically applicable to the delineation of some ore bodies with relatively simple shape and low degree of exploration. It is still unable to solve the problem of automatic delineation of paragenetic deposits and polymetallic deposits. At the same time, it is also impossible to carry out automatic classification of ore grades at the time of ore body delineation, and ore grade classification is one of the main tasks to be completed in the detailed investigation and exploration stage of ore body delineation. Geochemical information includes geochemical anomaly prospecting indicators, element anomaly and comprehensive anomaly map information and basic geochemical data information; Geophysical information includes geophysical indicators, mining area and regional geophysical information (comprehensive anomaly, method anomaly) and basic geophysical data information; Remote sensing information mainly includes remote sensing geological prospecting indicators, various interpretation graphic information and remote sensing basic data information; Engineering information is mainly represented by various graphic information, such as ore body map, borehole histogram, trench map, tunnel map, etc. According to the resource carrying capacity, current development density and development potential, and taking into account the future population distribution, economic distribution, land use and urbanization pattern of China, the land space is divided into four main functional areas: optimized development, key development, restricted development and prohibited development. The layout of regional mineral resources exploration, development and protection in the national mineral resources planning should be considered to be connected with it. The distribution law of mineral resources and its development and utilization status. Reasonable allocation of resources and environmental protection.

3. Digital Mineral Exploration and Prospecting Technology based on 3D Deposit Modeling Technology

3.1 Application of 3D Open Bed Modeling Technology in Digital Mineral Exploration

In order to improve the efficiency of mineral exploration, it is more important to use deposit modeling technology, which has been widely used in digital mineral exploration and has good application effect. However, there are still a series of problems in the application of deposit modeling technology before. Therefore, it is necessary to improve the modeling technology and digital information technology according to the current if shape of mineral exploration. Nowadays, 3D deposit modeling technology has been widely used in digital mineral exploration. Through the application of this technology, the accuracy of digital mineral exploration results has been significantly improved. Moreover, through the improvement of related databases, the application level of traditional deposit modeling technology has been greatly improved. Whether it is based on borehole geological interpretation or drawing section, the final result of 3D geological modeling method is mainly solid model, which is essentially

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the surface model of 3D geological body, that is, it is composed of closed Delaunay triangulation and is a storage data structure based on bin. The solid model has the advantages of fast display speed and small storage space, but it cannot store the physical and chemical properties of the internal units of the geological body, and it is difficult to carry out complex three-dimensional spatial analysis. If the attributes of the geological body need to be used in the later prediction, block modeling is required, such as the reserve estimation of the ore body in the mining area. The discrete points used for 3D block interpolation can be geophysical profile survey points, geochemical samples and rock samples collected from surface engineering (pit exploration, trenching, etc.) and underground engineering (such as drilling, adit, different middle roadway, etc.). However, it is generally necessary to have attribute fields that reflect the nature of geological bodies, which are best used for calculation.

The data source of this modeling is the catalog data of 102 boreholes and histogram maps in Ziziquan mining area, and the catalog map of Zhang tunnel; 1: 2000 scale geological topographic map, 1:1000 scale middle geological plan and 1:1000 scale exploration line profile of Xiquan mining area is all in MapGIS format. The format of SUPAC data is different from that of collected geological data, so it is necessary to extract borehole logging data and arrange them according to the format of SUPAC geological database. As shown in figure 2.

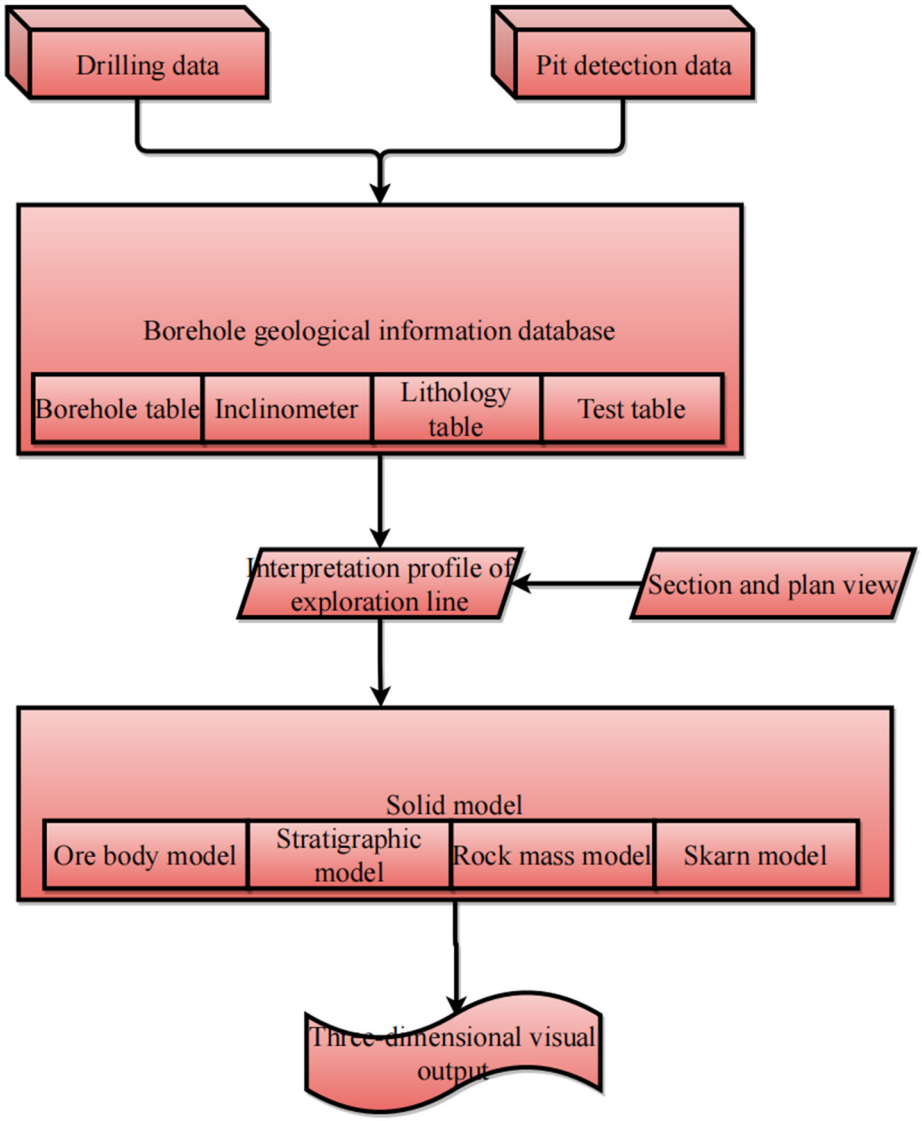

Figure 2. Flow chart of 3D geological modeling based on Surpac

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The block model is divided on the basis of the solid model. Only when the block is small enough can it meet the irregular solid boundary. However, the block is too small, which requires high hardware requirements of the computer, and leads to some simple operations that also take a long time. Therefore, the subdivision technology is used at the boundary of the solid model for automatic subdivision, so as to achieve the true shape of the solid boundary and accurate attributes. When building a block model, all kinds of solid or surface models can limit the block model, so that different rock masses and strata can be truly reflected in the block model, and use the test data of the geological database to determine the boundary of the ore body and report the overall or partial reserves to ensure that the requirements of mine design and production management are met.

3.2 Establishment of Ore Body Attribute Model

The spatial distribution model of ore body attributes is one of the necessary bases for ore body resource estimation and mining design. The modeling of ore body attribute model is mainly based on vector-grid hybrid model, among which TIN+ Octree hybrid model and Wire Frame+ Block hybrid model are the most widely used in ore body modeling. The establishment of surface model can accurately understand the actual situation of the whole mining area, and the mountain valleys on the surface have a certain degree of influence on the ground pressure of underground coal seams. Through the intuitive display of surface topography, we can intuitively understand the influence of surface topography on underground mining, such as ground pressure and permeable position. In addition, the ecological situation and living conditions of the whole mining area can be understood through the surface model. It plays an important guiding role in the site selection of other ancillary facilities in the mining area. The main difficulty of this part of the work is to transform the two-dimensional surface graphics and assign the elevation to generate the three-dimensional surface. It is a complicated process to organize a two-dimensional contour map that is not suitable for three-dimensional digital software into a three-dimensional contour map that is suitable for three-dimensional digital software. It is a huge workload to sort and assign the surface contour lines with a radius of tens of kilometers one by one. There are two types of 3D representation models used by Surpac for geological bodies. One is a solid model, which can accurately express the 3D spatial morphology of geological bodies such as ore bodies and rock masses, but the space between models and within entities is not divided into units; The other is block model, which uses regular hexahedron to partition between and within solid models by establishing constraints of solid models. In addition, it is necessary to realize intelligent connection of deposit types. In the process of intelligent connection, it is necessary to ensure that the ore body profile is intact.

In digital mineral exploration, the intelligent connection of ore body profile plays an important role, which is the main basis to promote the good application of 3D deposit modeling technology. In this intelligent connection process, the relevant parameters should also be set reasonably. On the basis of generating the spatial attribute model of the deposit, the block assignment of the attribute model is carried out. At present, the common methods of block assignment of ore bodies at home and abroad include inverse distance method, ordinary kriging method, indicator kriging method and pan-kriging method. The specific processing steps are as follows: first, divide the original samples into combined samples, then analyze the data of the combined samples to determine the distribution pattern of the samples, then understand the correlation of spatial sample distribution through structural analysis, and finally assign the block value to the attribute model through an appropriate estimation algorithm.

4. Conclusion

To sum up, it is very necessary to apply 3D deposit modeling technology in digital mineral exploration. Now the actual application scope of 3D deposit modeling technology has become more and more extensive. Through application in digital mineral exploration. From the current situation of prospecting and exploration, the development of a simple and practical prospecting and exploration information management system is the need of information prospecting. Through the analysis and classification of prospecting and exploration information, and on the basis of referring to a large

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number of domestic successful experiences, from the perspective of practicality, comprehensiveness and cost, a metal deposit prospecting and exploration information management system based on GIS platform has been designed and developed. Through the systematic study of three-dimensional geological modeling and visualization methods under different conditions in the mining area, the extraction method of multi-element comprehensive geochemical anomalies and the prospecting method of borehole primary halo, the three-dimensional geological modeling of Kekesala mining area was completed, and the comprehensive ore-indicating anomalies of borehole primary halo in the mining area were extracted. Through the three-dimensional integrated analysis and extraction of multiple metallogenic information such as geological, geochemical and geophysical information in the mining area, the three-dimensional metallogenic prediction of the mining area was completed by using the comprehensive information prospecting prediction method based on 3DGIS.

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