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Visualisation of Underground Mining Systems Based on Digital Mining Technology

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Abstract: Based on digital mining technology, this paper uses computer simulation as a means to realise a three-dimensional geological database and geological model creation, and to establish a three-dimensional underground mining system visualisation model. According to an underground mine mining system, research is carried out for the mining method and the realization way, and the design scheme and design parameters are proposed. The analysis of the mine geological data allows for a comprehensive digital integration and visualisation of the surface, the ore body and the pioneering system. It supports the operation of various software or systems related to mining design, research and production, and provides support for the construction of virtual mines.
Keywords*:* Digital Mines; Underground Mines; 3D Modelling

1. Background and Significance of the Study

With the rapid development of information technology and the acceleration of the process of global economic integration, market competition is intensifying, information technology is more and more widely used in all areas of social economy, information technology, networking, digitalization has become an important and basic means of social development today. Informationisation of enterprises is also receiving more and more attention, and the transformation and upgrading of traditional industries is a major trend. [1]With the booming development of information technology today, there are opportunities and challenges for the old mining industry, and the innovative development of the mining industry —the digital mine will become an inevitable trend.[2]

2. Digital Mine

With the popularisation of Internet applications and the development of network software technology, Web technology has evolved from only being able to provide pictures to now being able to deliver information in real time from all areas of the mine, allowing mining excavation data and remote information to be monitored and -warned in real time to help the mine to make timely countermeasures for unexpected situations that occur in time to minimise losses to the mine.[3] The future development of mines will gradually transform towards the popularisation of the "smart mine" model. Smart mines can intuitively, quickly and effectively realise data sharing and support functions for geological exploration, mining engineering, production, safety and other aspects related to the properties, design, pmonitoring and control of the volume field.[4]

The inevitable future trend of the digital mine has an open character system, the digital mine is composed of a series of software and hardware systems, its ability to achieve interconnection is due to the open and standard type of interface between the various systems, which can be customized to build the system according to its own overall planning and step-by-step implementation.[5] It is characterised by a 3D visualisation and a visualisation model that can be based on an engineering network to produce short-term targets in terms of production volumes and mineral grades. All subsystems of the underground mining process are automatically managed and centrally monitored and controlled during mine production.[6] The digital mine will be oriented towards an integrated optimisation system for the production process, which will collaboratively optimise all production stages and improve the overall operation of the mine.

3. Modelling Steps and Ideas

Based on digital mine technology, the 3D geological database and geological model are created by means of computer simulation,the 3D visualisation model of underground mining methods is established, research and simulation is carried out for unused mining methods and realisation routes, simulation analysis and modelling is carried out in conjunction with mine application examples, and design solutions and design parameters are proposed.

3.1 Geological Data Analysis and Geological Database Creation

Analysis and collation of basic data, forming "hole files", "skew files", "sample files" and "lithology files "The data will be analysed and verified to create a borehole database.

3.2 Geological Model Construction

The wireframe and block segment methods are used for geological modelling.

Wireframe method: A method that uses constrained lines to create a series of decoded shapes to represent 3D solid boundaries and contours. In essence, two adjacent sampling points or features on the target spatial contour are connected by straight lines to form a series of polygons, which are then stitched together to form a polygonal grid to simulate 3D solid boundaries. The block segment method: its storage address in the computer corresponds to its position in the natural deposit and its grade or lithological parameter values are determined according to kriging, distance-weighted averaging or other methods.

3.3 Research on the Implementation of 3D Visualization Methods for Mining Methods

There are two models of 3D design methods, one is bottom-up (partial→whole); the other is top-down (whole →partial). The bottom-up process is: sketch→feature →part→solid →engineering drawing.The modelling methods for 3D ore bodies are divided into three categories according to the type of information involved in the modelling: profile-based methods, planar-based methods, and mesh-based methods. Comparative analysis of 3D spatial modelling methods: spatial modelling methods based on the surface metamodel, spatial modelling methods based on the volume metamodel, and spatial modelling methods based on the hybrid surface-body model.

3.4 3D Solid Transformation

Exploring ways to realise 3D visual solid models in combination with 3D printing technology.

4. Mine Overview

4.1 Status of the Mine

The (111b+122b+333) resource reserves are: Ore 709728.8t; Metal 3209.305kg;Gold grade 4.52 x 10^{-6} . The gold resource reserves within the mine are shown in Table 1.

Table 1. Gold Resource Reserves within the mine area

Base Reserves						Resources		
Proven (researchable) economic base reserves (111b)			Controlled (pre-feasible) Economic Base Reserves(122b)			Amount of inferred embedded economic resources (333)		
Ore volume (t)	Amount of metal (kg)	Golden Taste	Ore volume (t)	Amount of metal (kg)	Golden Taste	Ore volume (t)	Amount of metal (kg)	Golden Taste
292492.2	1119.25	3.83×10^{-6}	306859.3	1427.877	4.65×10^{-6}	110377.3	662.178	6.00×10^{-6}

The production scale of the mine was initially: a daily processing capacity of 350~400 tons, with an annual output of 1300~1400 taels of gold, and a daily processing capacity of 600 tons for a large joint mining and processing enterprise with a daily processing capacity of 600 tons and an annual output of more than 20000 taels of gold.

4.2 Introduction to Mine Geology

The deposit consists of dozens of gold-bearing quartz veins, which can be divided into three gold-bearing quartz vein belts, No. 43, No. 28 and No. 38, respectively, from north west to south east, roughly arranged in parallel with equal spacing, inclined to the north west, with the main vein belt spacing of about 500 m. The vein belt is not only developed with gold-bearing quartz veins, but also densely distributed with a large number of vein rocks, while the schistocriticised amphibolite and sericite quartz micrite both have different degrees of The gold-bearing quartz veins are not only developed within the vein zone, but are also densely distributed with a large number of vein rocks, while the schistose porphyrites and sericite quartz micas have different degrees of gold mineralisation, locally reaching industrial grades, which are important mineralisation markers for the gold-bearing quartz veins. The following is a description of the characteristics of the No. 28 vein zone within the resource reserve verification of this mining claim.

Ore body No. 28 is the main ore body of the mine area, the ore body mainly consists of gold-bearing quartz veins, the surrounding rocks of the ore body are mainly diorite, diorite granite, schistophane, etc., the ore body is endowed with gold-bearing quartz veins, the production shape is consistent with the production shape of the veins, the ore body is orientated about 40° north east, inclined north west, dip angle 35~55°, the control length of the ore body is more than 2400m, the depth control to 290m elevation, the depth is more than 300m.

The ore body has a simple morphology with a relatively regular single vein output. The thickness of the ore body varies from 0.6 to 14.93m, with an average true thickness of 5.03m, with little variation in thickness along strike and trend, and is of a stable type. The grade of the ore body varies from 1.00 to 38.83g/t, with an average grade of 4.52g/t, with little variation in grade.

4.3 Introduction to Mine Design

The main shaft is a skip shaft (surface to Sixth Central Section), located between Lines 9 and 11, equipped with a 2JT1600/824 winch and a 1.03m^3 non-standard skip to lift ore. The secondary shaft is a cage shaft (from the surface to the eight middle section), located on line 13, equipped with a GK2×2×20 winch, 2# double-layered double tanks to lift waste rock and personnel materials.

Surface transport uses 7t electric locomotives and 1.8m^3 side-discharge mine wagons, underground transport uses 3t electric locomotives and 0.7m^3 overturned mine wagons. Underground ventilation adopts a central diagonal ventilation system, and the drainage method is step drainage.

5. Mine 3D Model

(1)Surface Model

This includes the main and secondary shaft industrial sites, the return shaft site, etc.

(2)Rock Model

It includes early Yanshan diorite granites, Hualixian black mica diorite granites, and diorites.

(3)Borehole Database

A total of 164 holes were recorded, and due to the large depth of burial of the proven ore body, no surface census trenching was recorded in this model.

(4)Orebody Model

(5)Shaft

Includes main shaft, secondary shaft, main slip shaft, east wind shaft, one section of blind shaft, two sections of blind shaft, etc.

(6)Stage Transport and Return Airway System

It includes the first middle section transport roadway system, the second middle section transport roadway system, the third middle section transport roadway system, the fourth middle section return air level roadway system, the fifth middle section transport roadway system, the sixth middle section transport roadway system, the seventh middle section transport roadway system, the eighth middle section transport roadway system, the ninth middle section transport roadway system and the tenth middle section transport roadway system, etc.

(7)The Effect of the Mining Area

(8)The Overall Effect of the Mine

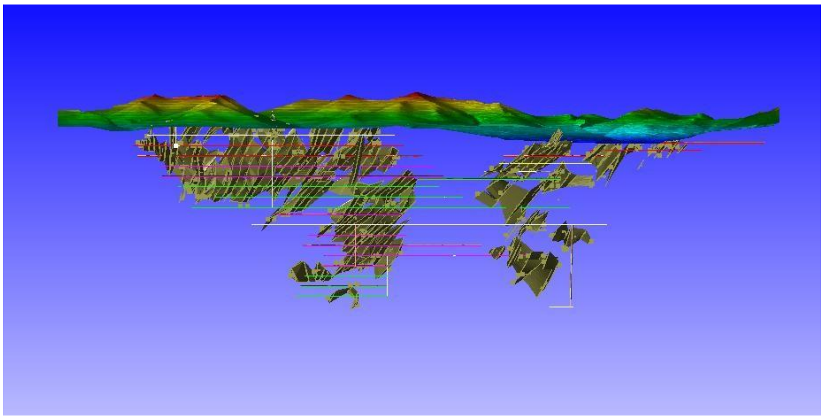

Figure 1. General view of the mine

6. Conclusion

Digital mine technology takes into account the technical characteristics of mine geology, surveying, mining and other production processes, and uses geostatistical theory, optimization methods, visualization and simulation technology, software technology, network technology and automation technology to build 3D geological models and resource value models, optimize mining plans, mining designs and production plans, monitor and manage the mining production process, ensure mine production safety, reduce mine The digital mining technology has brought a new level of competitiveness to mines. The emergence of digital mining technology has injected new vitality into the transformation of mine production technology and management models, leading to innovations in technical specifications, standards, processes and methods.

By analysing the geological data of the mine, a comprehensive digital integration and visual reproduction is carried out for the surface, the ore body and the pioneering system. With this as the core, it can support the operation of various software or systems related to mining design, research and production, providing support for digital mines. With the help of geostatistical theory, optimisation methods, visualisation and simulation technology, software technology, network technology and automation technology, 3D geological models and resource value models are constructed to optimise mining plans, mining design and production planning, monitor and manage the mining production process, guarantee mine production safety, reduce mine operation risks and enhance the comprehensive competitiveness of mines.

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