

# Research on the development of three-dimensional visual management system for mines: a case study of Chongqing Shuijiang aluminum mine

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**Abstract:** In recent years, problems such as unclear mine mining data and illegal mining have brought challenges to mine safety production, ecological environment restoration and mineral resources management. From the perspective of mine production and resource management, this study carried out research on the construction of 3D geological model and the development of visual management system based on multi-source data fusion, and selected the Shuijiang aluminum mine in Nanchuan District, Chongqing as the research object to establish a set of 3D visual management system for mine. The visual management system can reflect the production status of the mine in real time, and browse, query, section, reserve and statistics of the three-dimensional model of the mine, which has important practical significance for the supervision of the production mine.

**Keywords:** Multi-source data; 3D geological modeling; Visual management system; Shuijiang aluminum mine.

## 1. Introduction

At present, mining accidents caused by incomplete mine investigation and resource losses caused by mine super-mining often occur [1, 2], which increases the difficulty of mine production safety and mineral resources supervision, and excessive exploration and exploitation of mineral resources not only destroys the ecological balance but may also lead to a variety of geological disasters [3]. Traditional solutions such as wellwall support and legal sanctions are passive and limited. Therefore, it is necessary to establish a three-dimensional model and visual management system of the mine, clearly display the scale and production of mineral resources, and provide subjective and multi-functional operations.

Three-dimensional geological modeling is a technology that uses computer technology to combine tools such as spatial information management, geological interpretation, spatial analysis and prediction, geostatistics, entity content analysis and graphical visualization in a virtual three-dimensional environment, and is used for geological analysis [4]. This technology can effectively integrate and avoid the spatial incongruity and dissimilarity of multi-source data, and has been widely used in scenarios such as prospecting, reserve estimation and geological structure analysis. Taking

sedimentary basins as the research object, Li Lin et al. proposed a modeling method suitable for complex fault tectonic conditions, which can effectively improve the efficiency and accuracy of tectonic modeling[5]. Wu Zhichun[6], Wang Yong[7], Guo Yanjun[8], etc. applied different section modeling methods to different scenarios to achieve ideal results. Xue Linfu et al. proposed a block modeling method through repeated practice to solve the problem of large-area modeling [9]. In foreign countries, scholars have made a lot of explorations in three-dimensional structure and attribute modeling and three-dimensional visualization technology. For example, Lemon [10] et al. proposed a method based on drilling data and stratigraphic stratigraphic modeling, which can reduce human intervention in the modeling process. Li [11] et al. built a prediction model that can automatically identify regional minerals and predict future discoverable targets; Kemp [12] and others fused multi-source data to construct a three-dimensional geological model at the regional scale. The above results show that the data and methods of 3D geological modeling are diverse, and its model effects and application scenarios have been widely recognized by the academic industry, but they are not involved enough in enterprise production and department management, and the application prospects are great.

In summary, 3D geological modeling and visual management system have good application prospects in the field of mine production and resource management. In this paper, a multi-style 3D model of Shuijiang aluminum mine in Nanchuan District, Chongqing is constructed by using multi-source data and deep exploration software, and a visual management system is developed through ArcGIS platform, Cesium, Vue .js technology, which provides an online platform for mine production and department management.

## 2. Research and methods

In this study, a database was established based on multi-source data and multi-type 3D geological modeling was constructed, and a visual management system platform was built based on B/S structure development and the design idea of front-end and back-end separation (Figure 1). The basic data includes geological map, borehole mining profile and remote sensing image (Table 1), the 3D model includes the mine 3D geological model, ore body model, grade model and roadway model, etc., and the visual management system realizes the functions of transmission query, reserve calculation, roadway roaming and section cutting.

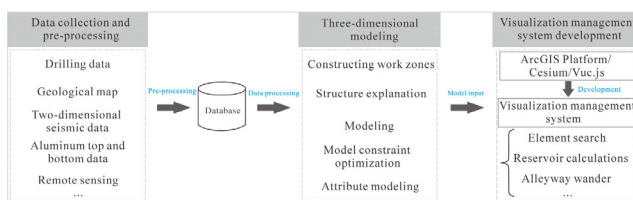


Figure 1 Research technical route

Table 1 Classification of 3D geological modeling data types

Data Type	Data Content	Primary Format	Purpose
Geological maps	Contours, stratification and production	mapgis	Geological modeling, ore body modeling
Wells	Drilling location, bearing and delamination	xlsx/las	Geological modeling, ore body modeling
Profiles	Series parallel profiles	dwg	Ore body modeling, roadway modeling
Aluminium ore content	Alumina content	xlsx	Modeling aluminium grades

## 3. 3D model building and system construction

### 3.1 Establishment of three-dimensional geological model of mine

Chongqing Shuijiang Aluminum Mine is located in Shuijiang Town, northeast of Nanchuan District, Chongqing City, the mining area is distributed in the two wings and overturned end of the northern section of Lujiaba anticline, there are no secondary folds in the area, the development area contains multiple faults and structural fractures, the strata are generally northeastern,

including 7 sets of strata from Lower Silurian to Lower Triassic, the oldest formation is the Hanjiadian Formation (S1h), and the latest strata is the Lower Triassic Jialingjiang Formation (T1j). The production mine has proven reserves of 3304.5 thousand tons of aluminum ore resources, mainly mining the aluminum ore of the Liangshan Formation of the Lower Permian system and the associated ore (ferferite and gallium), the aluminum ore layer is distributed in the upper part of the Liangshan Formation, the thickness is 0.37-2.52m, the average thickness is 1.36m, and the associated ferferite bauxite layer, the thickness is 0.53-2.50m, the average is 1.08m. In this study, Deep Dive was selected as a 3D modeling software, and the specific modeling process is as follows (Figure 2).

(1) Data preprocessing: extract the medium and high lines, fault lines, geological boundaries, production status, and profile information of the geological map, and finally output it in PRN file format; Organize the drilling data table, eliminate abnormal information, establish the opening coordinates, inclination table and grade table, etc.; The coordinate system of the unified remote sensing image, drilling and other data is CGCS2000.

(2) Construction and presetting of large work area: set the stereoscopic range parameters according to the mine plane range and drilling depth, establish the model work area boundary and import the corresponding data to the corresponding module.

(3) Stratigraphic and tectonic interpretation: combined with geological map plane information, drilling three-dimensional information, structural morphological interpretation information, comprehensive interpretation of mine stratigraphic lines and fault lines.

(4) 3D geological modeling: 3D fault modeling is based on the interpreted fault data to generate smooth surfaces, and the inaccurate parts can be corrected by editing boundary points and specifying the main and auxiliary relationship of faults; Stratigraphic 3D modeling is to generate the initial ground surface based on the interpreted stratum data under fault constraints, and then generate the stratum volume through strata node sorting, primary and auxiliary relationship definition, cutting and other processing. The three-dimensional modeling of the aluminum ore body is constructed based on its own top and bottom data; The roadway 3D model is a 3D model based on the mine mining map information.

(5) Aluminum ore grade modeling: define the grid size as  $X*Y*Z=2m*2m*1m$  according to the spread characteristics and thickness of the ore body, create a truncated mesh model of the aluminum ore body, assign the grade value of aluminum ore to the drilling model in the grid module, and use kriging method for layered interpolation, so that all ore bodies can obtain grade values.

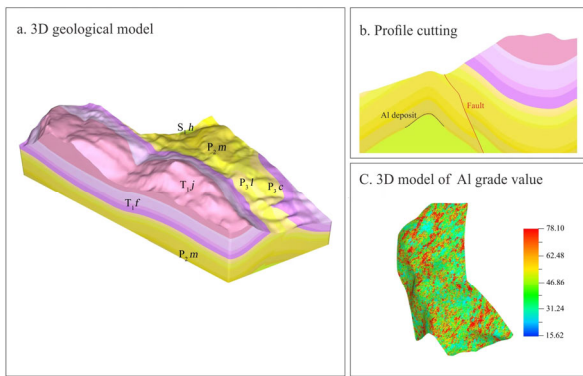


Figure 2 3D modeling results

(a) Three-dimensional geological models; (b) display of local cross-sections of the model; (c) Aluminium grade property model

### 3.2 Visual management system construction

In order to solve the problems of difficult management of underground mineral resources and limited monitoring methods of relevant departments, a three-dimensional visual web terminal system suitable for mineral resources management was built in this research and development. The visual management system is developed based on the B/S structure and adopts the design idea of separating the front and back ends. The front-end uses Vue .js to quickly build a user interface, using ArcGIS API for JavaScript and Cesium as a visual framework for two-dimensional and three-dimensional maps, and the back-end basic platform layer selects ArcGIS Server components to achieve the distribution of GIS resources and the response to user requests, in which the data layer uses MongoDB to manage data such as three-dimensional geological models and slices, and stores two-dimensional geographic data and entity attributes through PostgreSQL. In the system, the application functions such as 3D geological model release and sharing, feature query (including strata, borehole, fault, fold, ore body, roadway, goaf, etc.), basic calculation (involving line, surface, volume and other elements), reserve calculation, section cutting and other functions are mainly based on JavaScript and other languages (Figure 3).

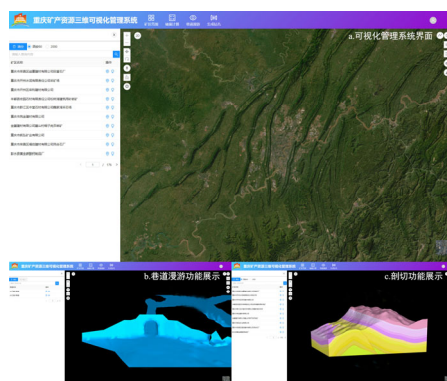


Figure 3 Visual management system interface and some of its functions

(a) Visual management system interface, (b) roadway roaming function, (c) section cut display

The visual management system includes functions such as 3D geological model browsing, sectioning, attribute query, reserve calculation, layer control, measurement, drilling generation, and roadway walking. (1) The browsing function can realize intuitive viewing of the web 3D model in the system, and realize rotation, zooming, zooming, panning and other operations through the corresponding buttons; (2) The sectioning function can realize the section cutting of the three-dimensional model and dynamically view the morphological characteristics of the internal structure of the model; (3) The attribute query function can right-click to view the attribute information of the model, such as formation name, attribute ID, etc.; (4) The reserve calculation function can realize the input coordinates or manual box selection to delimit the range, and double-click to find the ore body reserves in the range; (5) The measurement function can realize the calculation of model length, area, elevation and other information; (6) The layer control function can realize the model layers required for custom display, such as transparency, color and other content; (7) The drillhole generation function can view the drilling pattern of the exploration ground and query the lithology and height of the interspersed formation; (8) The roadway roaming function can realize the virtual scene of the roadway from a first-person perspective.

### 4. Conclusions

In this study, the construction of the 3D geological model and visual management system of Shuijiang Aluminum Mine in Nanchuan District, Chongqing was realized, and the real-time 3D model and diversified management system were provided for the mine production and management department. Among them, the three-dimensional geological model can show the production of the mine and provide an important reference for later mining. The visual management system queries and analyzes the input 3D geological model, which can be applied to mineral resources management.

In addition, there are still some shortcomings in this study: in the process of 3D geological modeling, there is no consideration of whether the amount of data is sufficient and whether the drilling data is evenly distributed, and the accuracy and details of the 3D model need to be further improved. More practical functions can be developed in the visual management system, such as model explosion, early warning prompts, etc.

### Acknowledgements

Natural Science Foundation of Chongqing Municipality (cstc2020jcyj-msxmX0962); 2020 Geological Exploration Project of Chongqing Municipal Bureau of Planning and Natural Resources (3D Geological Modeling of Chongqing 1:50,000 Regional Geological Survey).

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