ISM COMMISSION Ⅱ first meeting

中国煤炭科工集团 CHINA COAL TECHNOLOGY & ENGINEERING GROUP

透明矿井 TRANSPARENT INTELLIGENT MINING

Digital Geology Support Technology

-Creating “Digital Holographic Geological Map" for Intelligent Coal Mines

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2024

About Us

2018 Top-level design
2019 TIM Institute
2020 Integrated Solution
2021 TGS Center,
2022 RDCs regional delivery centers
2023 TGC, Xi’an CCTEG Transparent Geology Company

CONTENTS

《Transparent Geological Map》(Xianyang Airport)

Part 1

Background

- 1.1 **Technical Background**
- 1.2 **Production Requirement**
- 1.3 **Key Point**

Coal Mine Disasters are Closely Related with Geological Factors

- Coal mine faces **disasters such as coal and gas outburst, rock burst, water hazard.** Intelligent production mode brings new challenges to disaster monitoring in terms of **comprehensive perception** and **real-time early warning.**
- **Geological anomalies** are the main cause of induced disasters, and all disasters are closely related to hidden disaster-causing geologic factors

Current Status of Geological Support

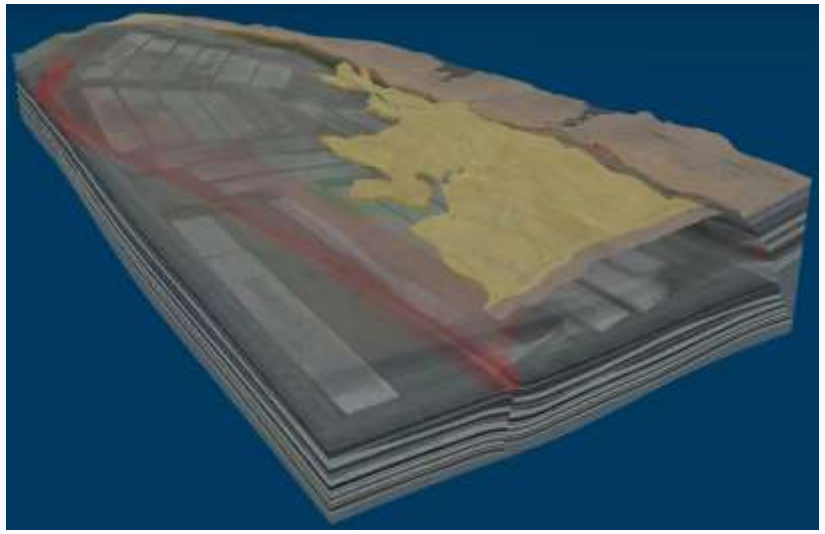
- Pre-mining: **Low accuracy in detecting geological anomalies,** insufficient control, characterization of geological factors;
- During mining: **Insufficient equipment for monitoring the dynamics of geological anomalies**; lack of means to describe the processes of dynamic changes in geological hazards

water hazard

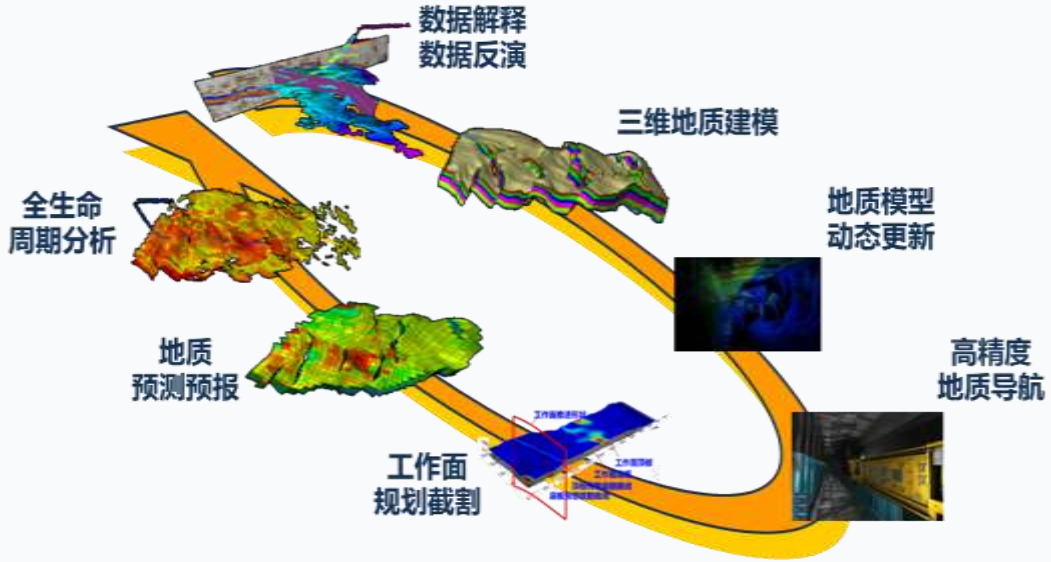
rock burst

gas outburst

- **Transparent Geology Support System** for Intelligent Coal Mines(**TIM-CLOUD, Transparent Intelligent Mining Cloud Platform) is based on comprehensive geological model (holographic geological map)** to improve the real-time, shared, standardized, and reliability of geological data. **Real-time spatial coordinates of coal-rock interfaces** and **geological navigation models** for intelligent mining are provided through full-lifecycle geological information, engineering information sharing, collaborative processing mechanisms, and 3D interactive visual analysis. Technical support for **transparent analysis and evaluation** of hidden disasters is also offered.



Holographic geological map



Transparent geological support throughout the full-lifecycle

《Transparent grid》(Ordos)

Part 2

Overview

- 2.1 **Tech-Revolution**
- 2.2 **Full information model**

The most important transformation： From presenting information in a single image to sharing data resources+the creation of intelligent scenarios

Three-level technical systems: data level, model level, and system level

Technical difficulty: linkage and real-time update of data, graphics, and models

Technical route: Build a three-layer technical architecture of data-model-system to create a highly cohesive and low-coupled software system. Through the aggregation and decoupling of geological data, achieve data-information-knowledge sharing and reuse.

Profound perception、Fusion of virtual and real、Intelligent analysis、Collaborative management and control

2D to 3D | **Threshold to system**

singular to collaborative

Static to dynamic | **Local to global**

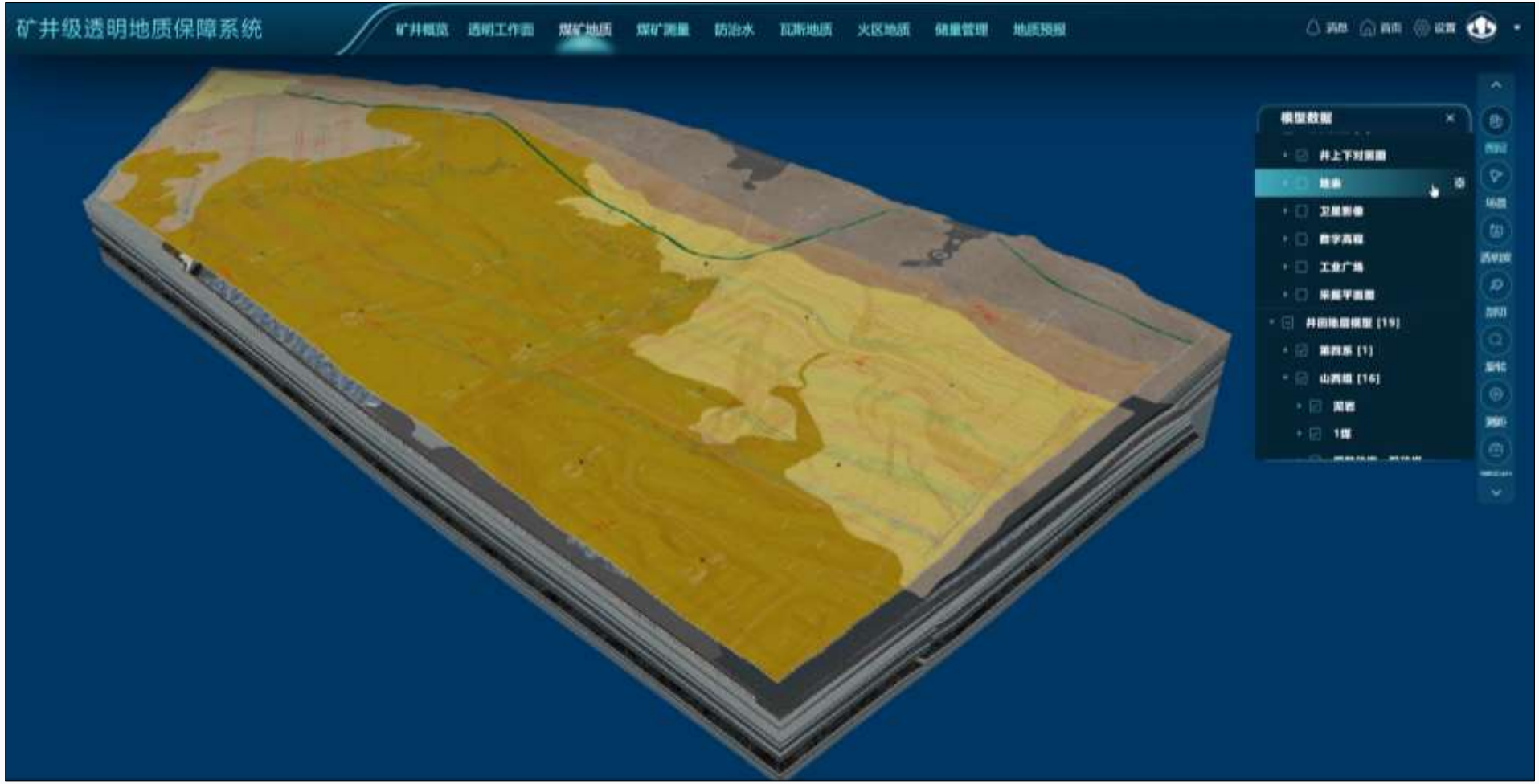
Multi-scale, all elements

Multiple disasters, full-process

3D computation | **Spatial analysis**

Coal mine roaming

Multi-source fusion, holistic visualization, and dynamic updates



Strata, structure, surface, tunnels, equipment, hazards, assessment

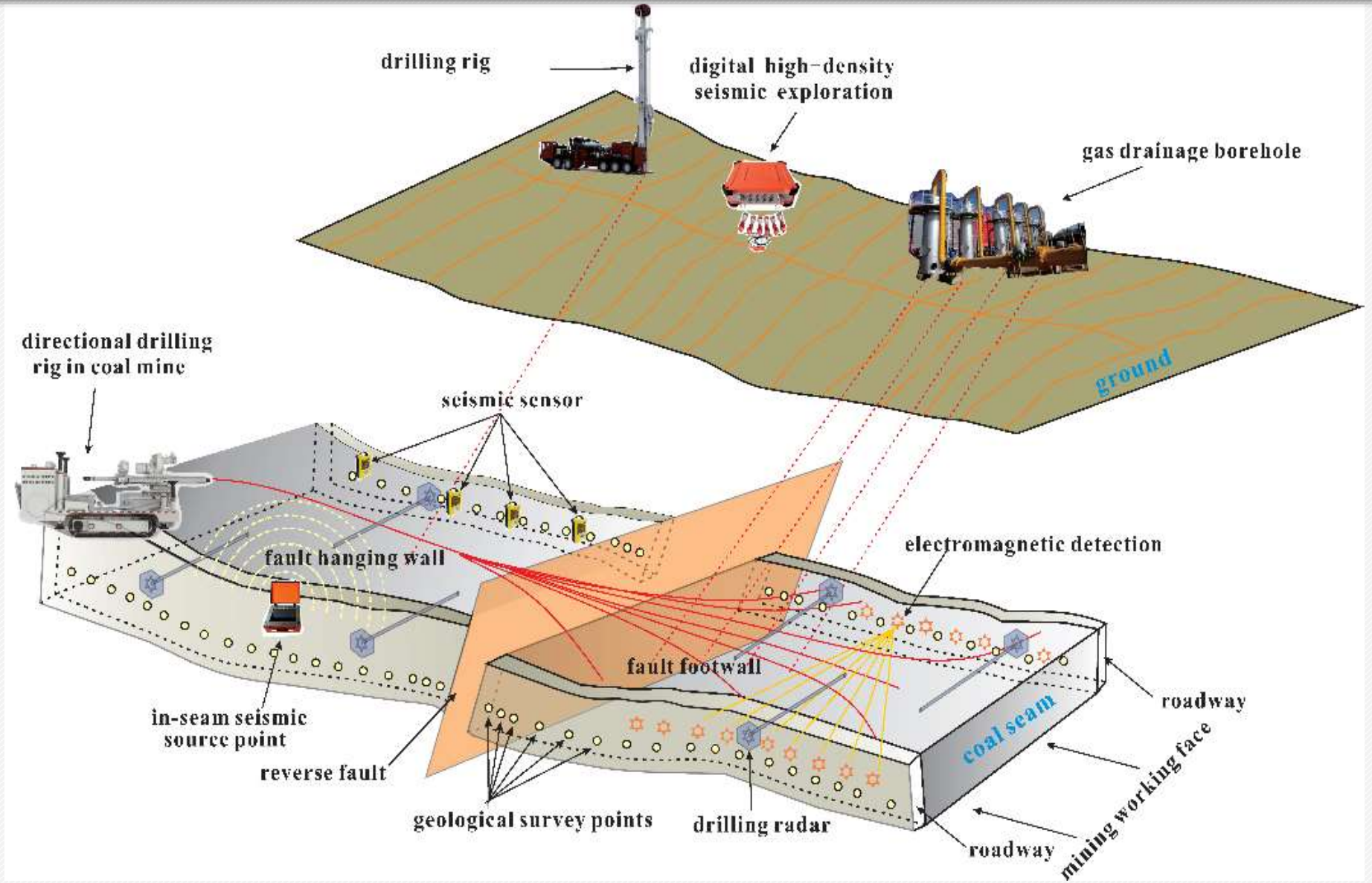
Full Information Geological Model

《Crossing the horizon》(Wuhai)

Part 3

Key Techniques

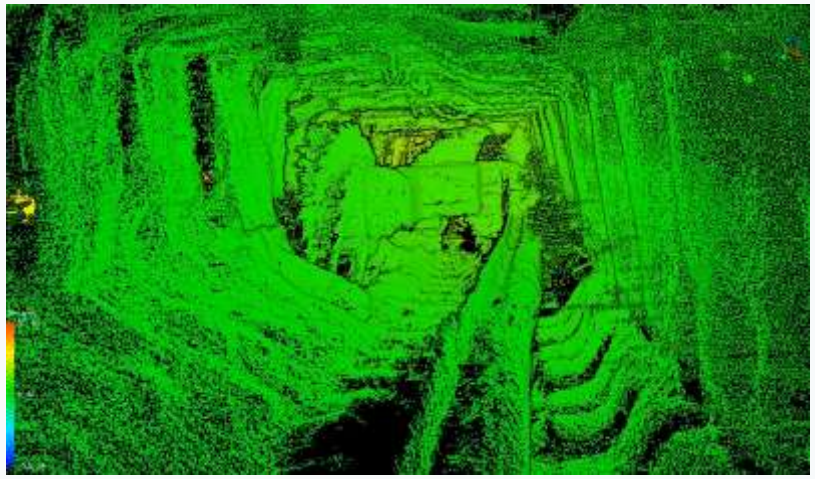
- 3.1 **Data Foundation**
- 3.2 **Model Construction**
- 3.3 **System Empowerment**



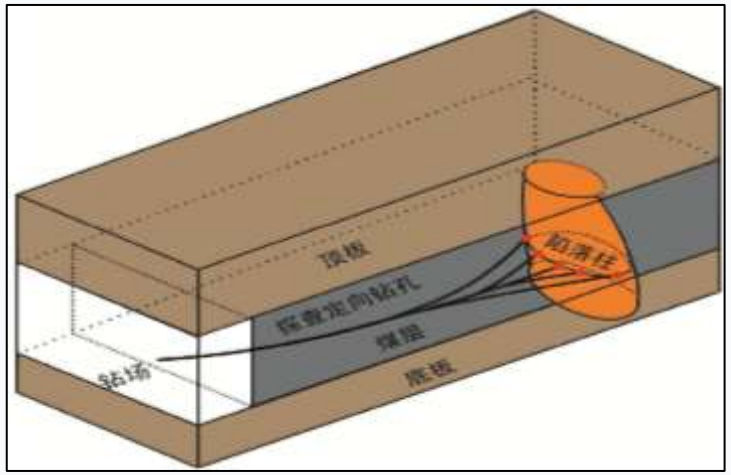
Multi-source heterogeneous geological data

High-precision data collection technology of transparent geology

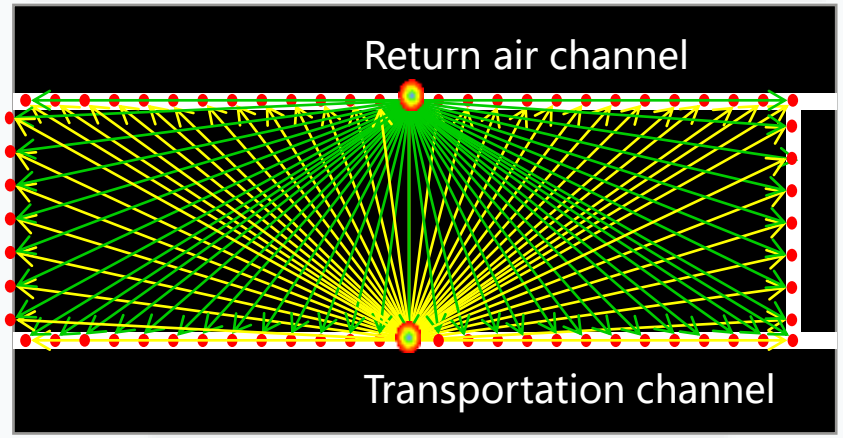
High-density 3D seismic exploration



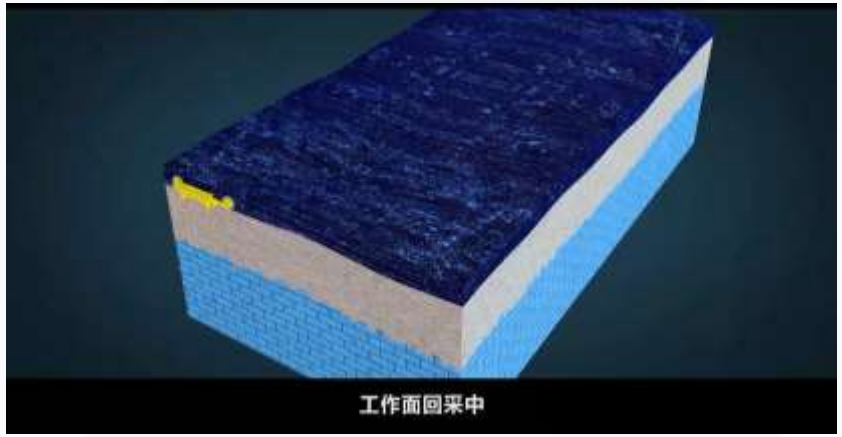
3D laser radar scanning



Long-distance directional drilling



Channel wave seismic detection



Seismic monitoring during mining and excavation

Borehole geophysical radial detection

Data transparency, high-precision detection, and data fusion for comprehensive geological perception

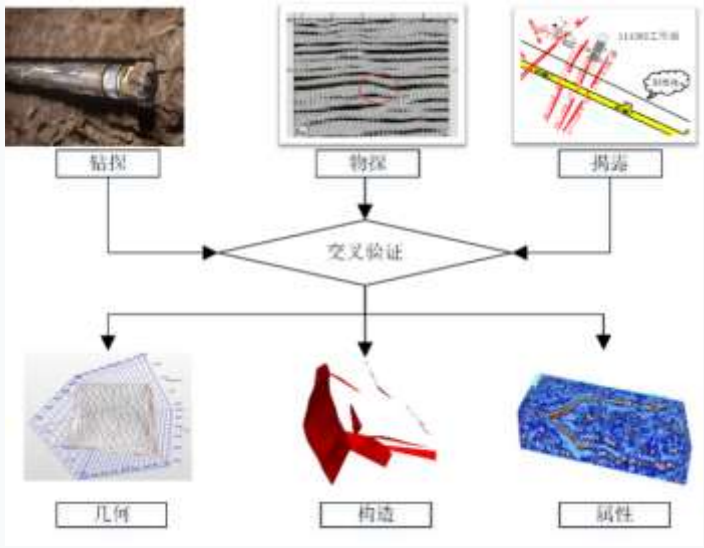
Proposed:

- Multi-source heterogeneous data fusion technology for coal mines, including data classification, spatial registration, cross-validation, data processing, and seismic data dynamic calibration.

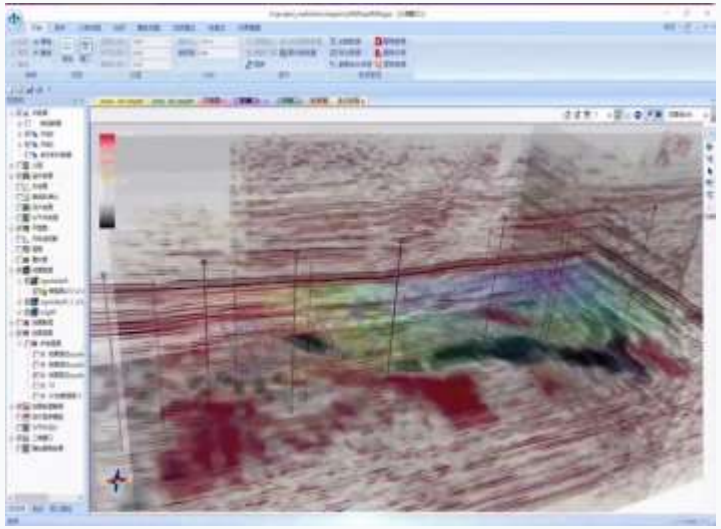
Developed:

- The transparent workface multi-source data fusion system v1.0 (Registration number: 2021SR1627996)
- Comprehensive management platform of coal mine data V1.0 (Registration number: 2022SR0978798)

Long drilling and long exploration



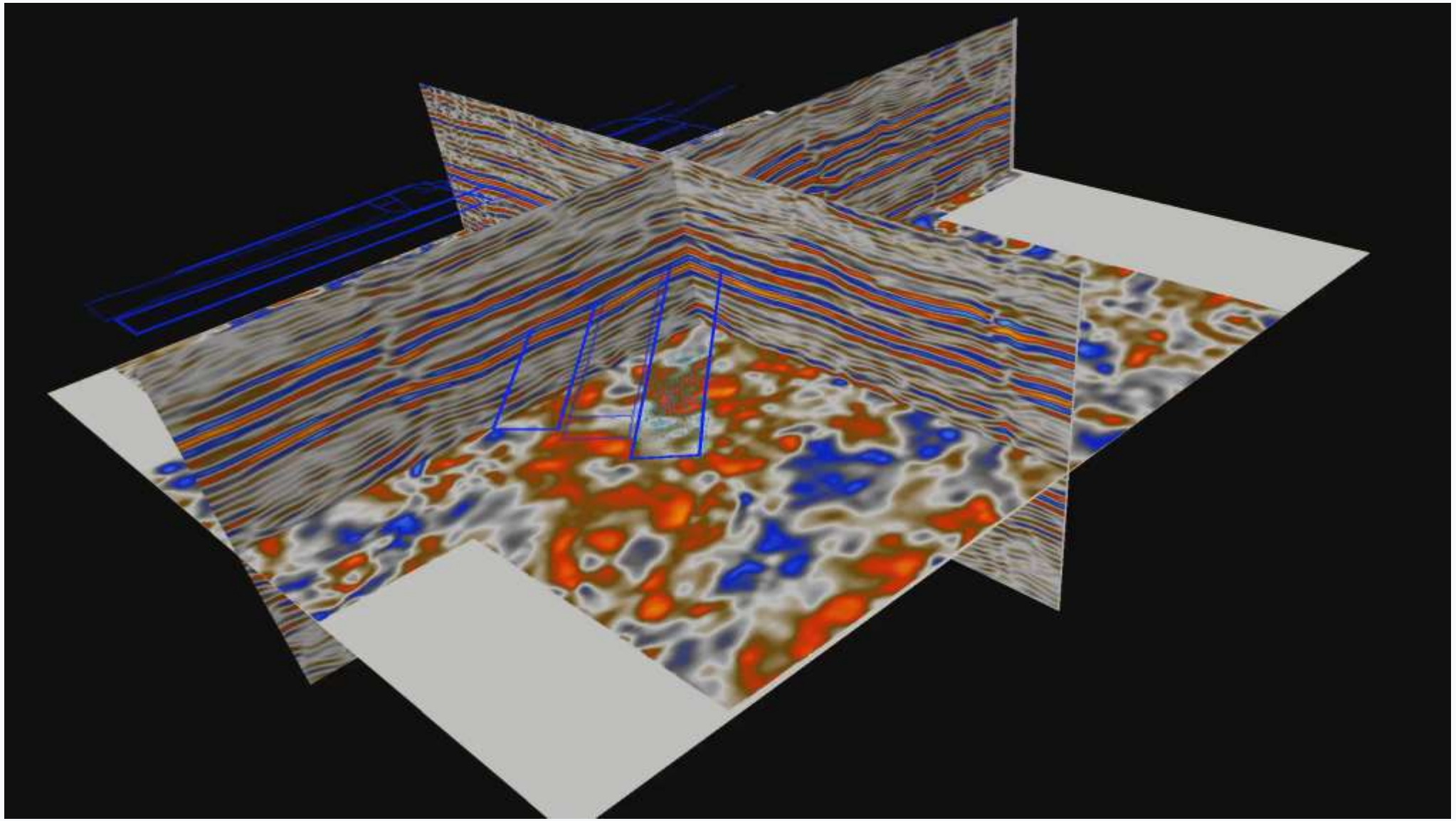
Data fusion



Unified data structure

- **The resolution for technical challenge of creating a unified and high-precision geological data structure;**
- **The capability for fusion and calibration of data from drilling, seismic, channel wave, electromagnetic methods, and dynamic detection of seismic.**

TJH data fusion



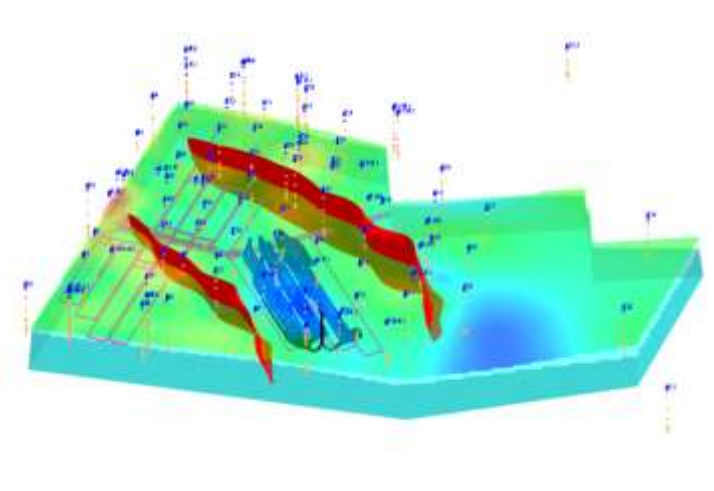
Information transparency, 3D geological modeling, and geological information mapping create a full-information geological map

Proposed:

- Constructing a multi-attribute geological model including hydrology, gas, mine pressure, and other information to realize the visualization of disaster geological elements;
- Mapping dynamic geological response information from mining operations to a 3D geological body in real-time, realizing transparent representation of concealed attributes.

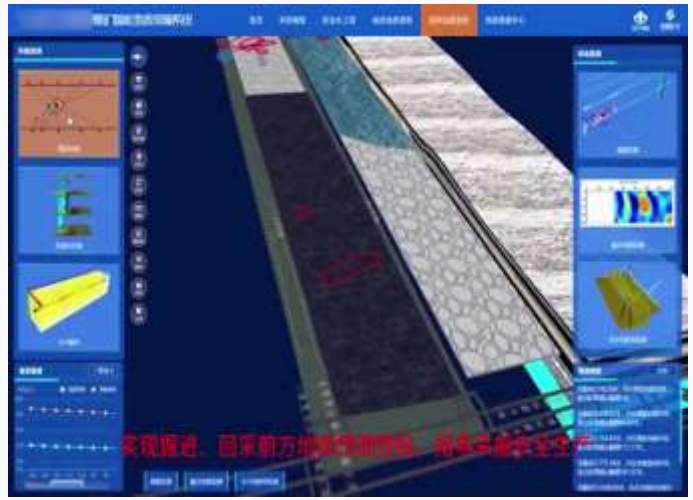
Developed:

- TIM-3D geological modeling system（Registration number: 2020SR099 3021）
- Workface geological visualization system（Registration number: 2019SR0450338）
- 3D hydrogeological modeling software v1.0（Registration number: 21SR1627983）



Construct model

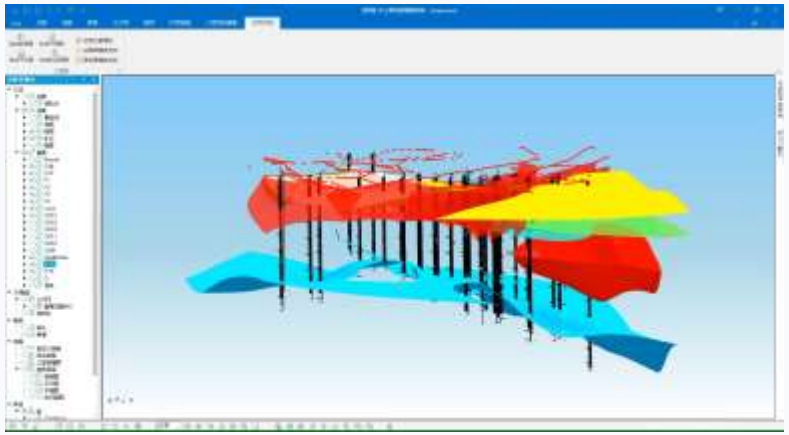
Attribute model



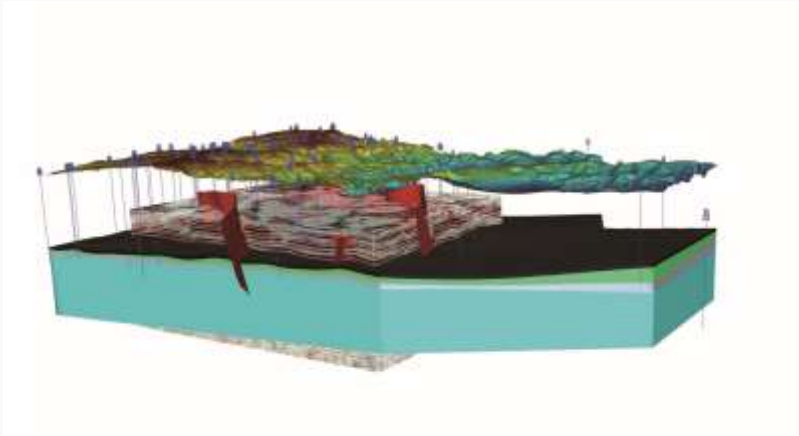
Dynamic model

- **Solving the problem of constructing high-precision, multi-attribute, and dynamic geological models;**
- **Constructing complex geological models for coal mines, analyzing disaster attributes, and realizing simultaneous mapping of hidden disaster-causing factors on a 3D geological platform.**

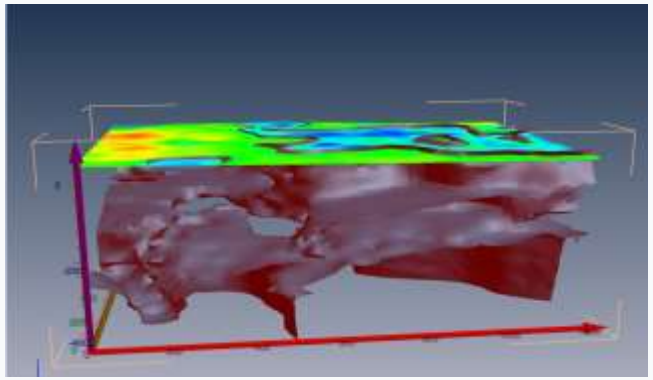
Dynamic multi-attribute geological modeling



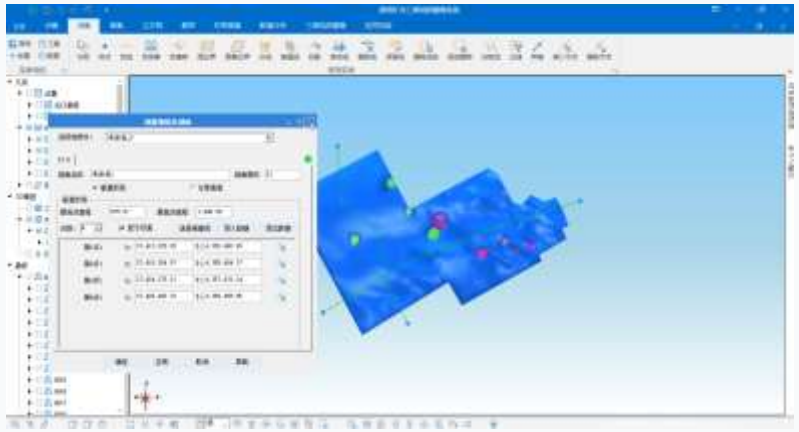
Full stratigraphic entity modeling



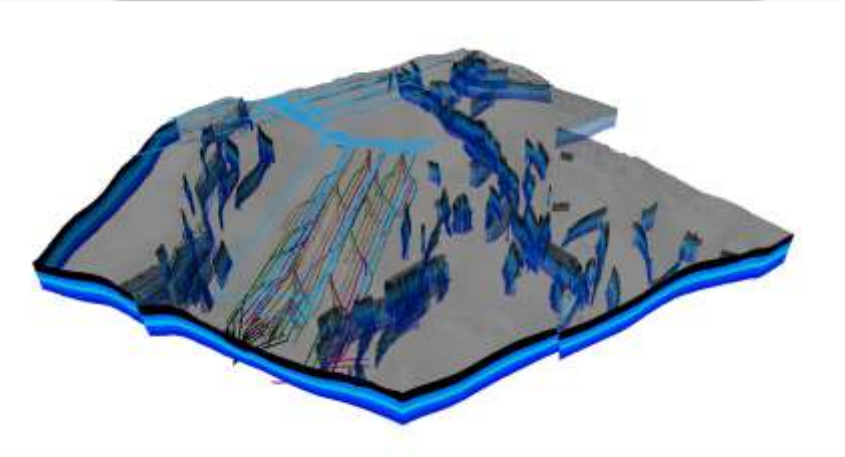
Complex structural modeling



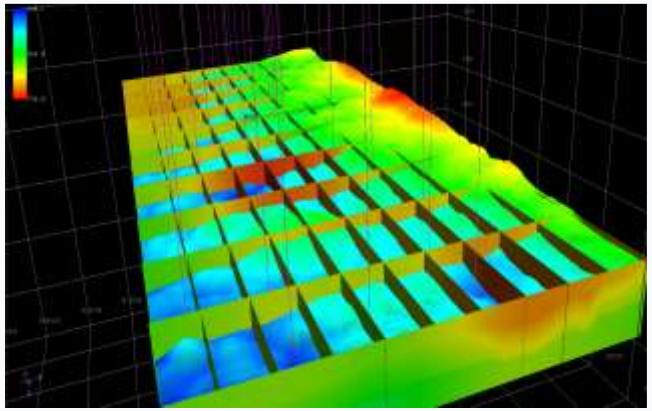
Hydrogeological model



Arbitrary sectioning of the geological model



Integrated geological model



Multi-attribute geological model

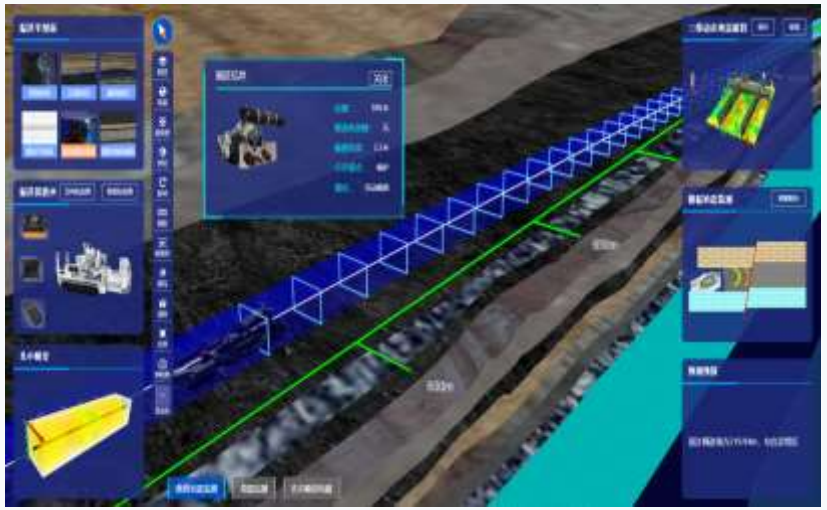
Knowledge transparency, planning cutting and geological forecasting to achieve transparent mining

Proposed:

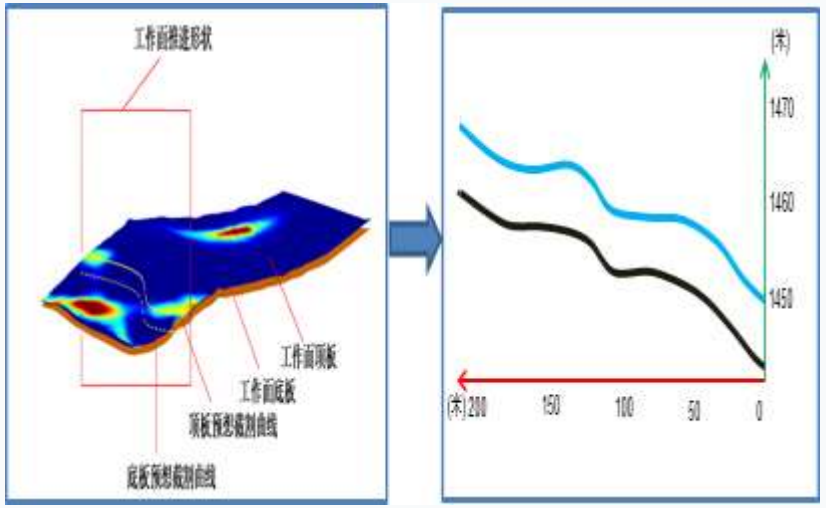
- A data distribution method for real-time updating of accurate working face geological model, which is based on pre-mining multi-source information detection and mid-mining joint monitoring, provides geological navigation for mining and digging, and promotes the upgrading of coal mining from memorized cut-off to intelligent and planned cut-off.

Developed:

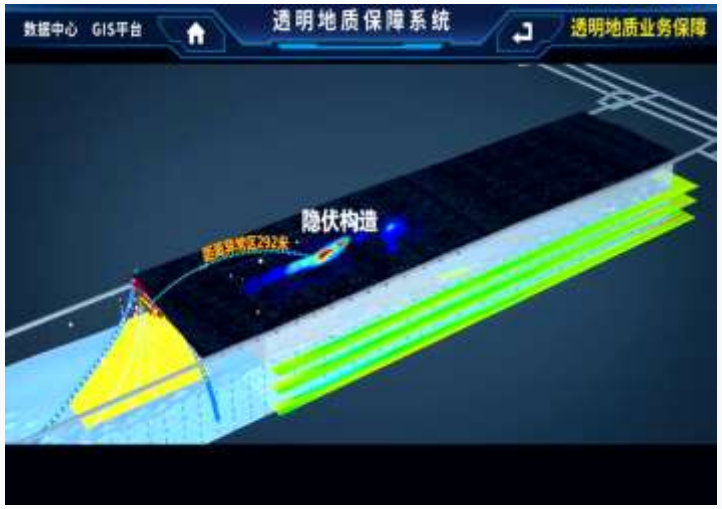
- Transparent workface digital twin system (Registration number: 2020SR1242124)
- Transparent mine platform (Registration number: 2020SR1242116)
- Transparent mine cloud GIS platform C1.0 (Registration number: 2022SR0978799)



Excavation navigation



Planning cut-off



Prediction and forecasting

- **Achieving real-time feedback and coordination between the geological model and coal mining machine information;**
- **Integrating mining engineering data and real-time monitoring data from the workface for dynamic correlation analysis, enabling intelligent geological prediction.**

Coal mining machine planning cut-off

Technical route

Grid divide of 2D layered digital model

↓

Discretize cutting path

↓

Calculate the plane coordinates of the discrete point

↓

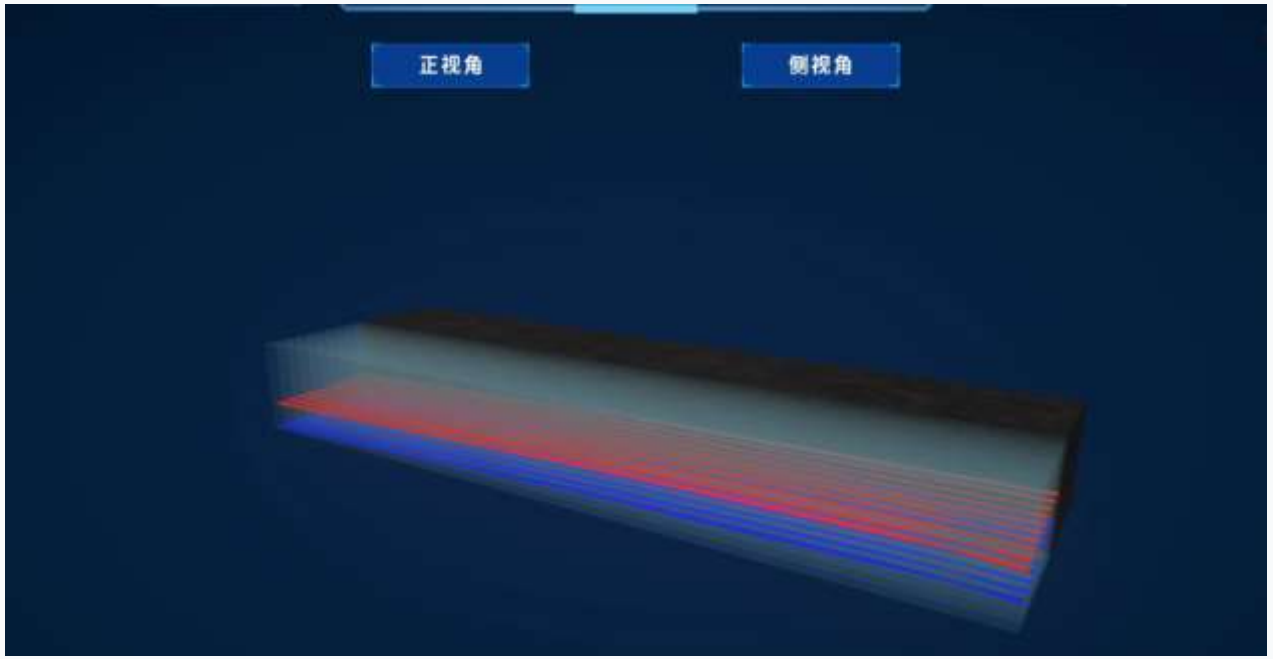
Fit the roof/floor elevation corresponding to each discrete point to obtain the roof/floor interface curve

↓

Optimize control parameters

↓

Command issuance and digital cutting



- Using "CT" cutting and slicing technology to **generate a planning cut-off model**;
- **The open-off cut roof/floor interface obtained based on "CT" slicing technology** is combined with the mining process to optimize control parameters such as cutting trajectory, cutting drum height adjustment/ undercover, bracket movement, and pull frame advancement;
- The centralized control center transmits control parameters to the coal mining machine at the fully mechanized mining face through industrial Ethernet, enabling **digital cutting in intelligent coal mining**.