Research and Application of Unconventional Gas Wellsite Ground and Underground Integration System

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Abstract. Based on the coalbed methane ground, geology, production, engineering big data applications, as well as the construction of an on-ground and underground engineering geological integration database, we considered establishing a unified wellsite deployment platform. The SOA data-service-application framework is adopted to realize intelligent management of gas fields. We developed functional modules such as wellsite deployment inquiry, wellsite deployment environment research, and program optimization report. We realized the deployment of ground and underground also the geological engineering integrated wellsites to reduce the waste of time resources and human resources caused by the contradiction of underground and ground deployment.

Keywords: Unconventional gas · Integral · Wellsite deployment · Well location visualization · Scheme optimization

1 Background

In recent years, with the development of the "standardization design, information management, modularization, and marketization operation" in China's oil fields, the construction and development of China's oil fields have been strengthened in some extent. At the same time, in the course of work development, not only has the working environment of the oil and gas fields been improved, the management system and

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management mechanism have been strengthened, but also the safety and reliability of the oil field work have been improved, and the innovation and development of the oil and gas field ground engineering and underground exploration technology have been accelerated [1].

Shanxi Coalbed Methane Company began to gradually build a smart gas field platform through overall planning. After continuous construction in recent years, it has gradually established a unified database and a unified system platform, and now has the basis for application construction on the platform. For the coalbed methane business, currently there is no complete set of functional applications based on the central database, such as geological basic research, drilling design and drilling while drilling, modeling seismic research, and rapid decision-making, so that researchers spend a lot of time and energy on basic research work. They cannot achieve rapid, efficient, visual, interactive comprehensive research and rapid decision-making.

At present, wellsite deployment research and decision-making are carried out by geology. We first take coal seam geology research to carry out well location deployment and then make sure engineering ground site survey to determine whether the well location is appropriate. If the ground project does not support the geologist's decision, then conduct another study and adjustment. We have not unified 3D platform to realize the synchronous communication of underground and ground to deploy wells, which leads to the conflict between the deployment of geological wells and ground engineering, which leads to heavy losses. The program optimization relies on human experience, wasting a lot of time resources and human resources and affecting the process of drilling program [2].

Therefore, a unified wellsite deployment platform needs to be established. Through the visual research of topography, subsurface reservoir seismic and 3D geological models, with the aid of data such as ground protection zones, roads, and pipe networks, will be better to determine the favorable deployment areas for underground and ground linkages [3]. For the analysis of terrestrial big data and underground data, it can give us many feasible well trajectory deployment plans. Then, we can select the most suitable plan and form a report. Decision-makers can optimize the program according to the proportion of their importance based on factors such as production data, benefit analysis, and safety, so as to improve the efficiency of wellsite deployment and development efficiency.

2 Overall Design

We use the ground and underground engineering and geological integration database. A unified wellsite deployment platform was established, and it adopts a SOA data-service-application framework, business design for wellsite deployment [4]. We have developed functional modules such as wellsite deployment query, wellsite deployment research environment, program optimization report generation, program superiority evaluation, and so on. It can reduce the waste of time resources and human resources caused by the contradiction of underground and ground deployment.

The above-ground part relies on a 3D GIS system to realize the requirements for coalbed methane production, exploration, development, management, and application. Based on the topographic data and satellite remote sensing data, it collects wells, stations, pipe networks, communications, roads, houses, farmland, etc. [5] Through digital technology processing, the real scene of the production area is reproduced. Based on three-dimensional scenes to demonstrate the professional system processes, information query and application analysis include:

1. Topographic database construction, construction of ** and other blocks of 3D terrain database.
2. The construction of three-dimensional GIS on the ground to achieve visual query, display, and so on.
3. We establish the ground marker data classification model. Facilitate the collection and analysis of information on roads, lakes, houses, farmland, and other goods on the ground.
4. We develop the production data interface. Provide necessary interfaces for data resource pools, automation systems, material systems, and pipeline systems, in order to achieve data sharing.

Underground section: Through underground geological three-dimensional modeling, the seismic data volume of the coal seam research, the demonstration of the three-dimensional geological modeling results, the roaming, the sculptured body, and the arbitrary cutting are realized. In the three-dimensional environment, the free invocation of the seismic data body and the well static geological data are combined and displayed, assisting the researcher to accurately understand the structural characteristics of the coalfield. The mutual verification of single wells, multiple wells, and seismic data was realized. And for the favorable reservoir display, the seismic and geological information can be performed very fast and visually show the favorable geological reservoir shape and location [6].

Finally, a navigation window for the integrated wellsite deployment of underground geological and ground engineering will be established. Realize three-dimensional visualization of seismic data volume, geological modeling, and topography. It can perform arbitrary sectioning and intuitively view the favorable deployment area of the underground and ground, the location of favorable reservoirs, and the ability to conduct inquiries on ground protection areas, roads, farmland, electricity, and pipe networks, and fast and accurate navigation of well locations [7].

3 Well Location

3.1 Basic Geological Research

Based on three-dimensional navigation, we can quickly perform single well drilling, recording, testing, and other data research and well comparison analysis (Fig. 1).

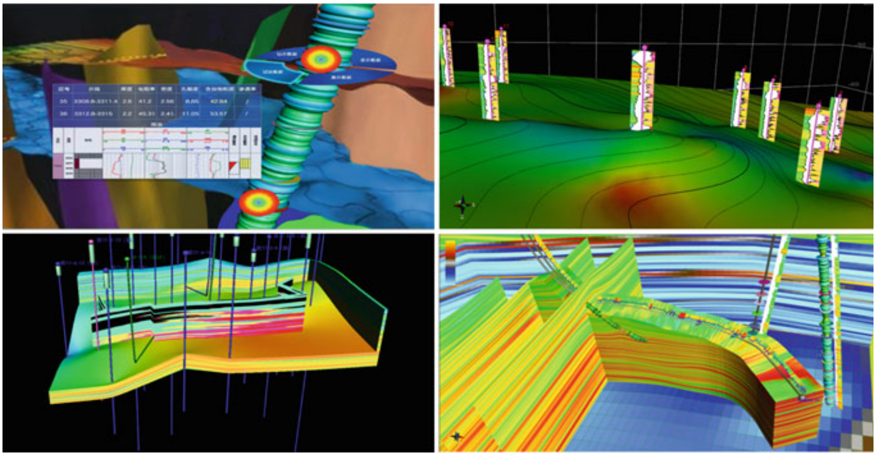

Fig. 1. Comparison of drilling, recording, and testing data

3.2 A Variety of Drilling Trajectories and Well Design

On the one hand, the system provides a conventional well design method and a variety of drilling design methods, deploys the ground and underground favorable area according to the wellsite, and provides a variety of horizontal well drilling trajectory design tools. At the same time, various well types such as vertical wells, cluster wells, horizontal wells, and branch wells are provided different method to adapt to different environments.

3.3 Identification of Common Favorable Areas on the Ground and Underground

Through the superposition analysis of the plane reservoir distribution and the favorable areas on the ground, it shows the differentiated display of the favorable areas in the three-dimensional space. We can visually inspect the favorable areas on the ground, underground reservoirs, and common vantage.

3.4 Wellsite Deployment Plan

Through the superposition analysis of the flat reservoir distribution and the favorable areas on the ground, three-dimensional space model and terrain display and visually inspect the favorable areas on the ground, the underground reservoirs, and the common favorable areas. According to the spatial location of the ground and gas reservoirs, the use of large-scale data technologies such as topography, land surface engineering and sensitive sources, underground gas reservoir distribution, well trajectories, existing wellsites, and human–machine interactions proposed multiple sets of drilling feasibility deployments plan (Table 1).

Table 1. List of feasible plans for wellsite deployment

Deployment plan	Block	Gas layer	Common area of favorable area	Main well type	Reservoir area	Number of deployed wells	Three-dimensional model
Program 1	**	8	2.5	Straight well	2.5	100	Details
Program 2	**	8	2.5	Cluster well	2.7	110	Details
Program 3	**	8	2.5	Horizontal well	3.0	50	Details
Program 4	**	8	2.5	High inclination well	2.7	110	Details
**	**	**	**	**	**	**	**

**Hide sensitive information such as well numbers and place names

3.5 Multi-Window Linkage Deployment

According to the specific needs of users to deploy wells, they can quickly link the basic data and geological research results of the "Smart Gas Field" platform, establishing a wellsite deployment environment for capacity building in the new area and capacity building in the old area and deploying well locations through online multi-window and multi-map linkage to improve wellsite deployment efficiency.

(1) New wells intelligent deployment in the new district: Through the multi-layer, multi-window linkage technology to obtain various types of geological result maps, carry out the study of the simultaneous deployment of ground and underground wells.
(2) New wells intelligent deployment in the old district: Based on the deployment of required result maps for new wells, and for the case of new wells in the old districts, the old area encryption and so on, rapidly increase relevant result maps and generate the data which needed to implement the deployment well location.

Comprehensively consider the ground equipment, topography, and coal seam geology to perform wellsite deployment demonstration, achieve underground and ground integration, and generate wellsite geological design tables (Table 2).

Table 2. Wellsite geological design table

Well name	Target	Coordinates		Prediction layer			Design target				Sensitive source hint
		Vertical	Horizontal	Top elevation (m)	Bottom elevation (m)	Coal thickness	Altitude	Distance to the oil top(m)	Distance to oil base(m)	Horizontal section length(m)	
**Well	1	**	**	−670	−680	10	−674	4	6	0	Sensitive source: There are 5 kV high-voltage power lines at 500 m from the wellhead and processing stations at 2 km from the wellhead Suggestion: offset 1 km to the northwest from the wellhead
	2	**	**	−671.5	−681.5	10	−675.5	4	6	103	
	3	**	**	−673	−683	10	−677	4	6	206	
	4	**	**	−674.5	−684.5	10	−678.5	4	6	306	
	5	**	**	−676	−686	10	−680	4	6	398	
	6	**	**	−677.5	−687.5	10	−681.5	4	6	498	
	7	**	**	−679	−689	10	−683	4	6	603	
	8	**	**	−680.5	−690.5	10	−684.5	4	6	703	
Wellsite coordinates: *X*-axis**; *Y*-axis**; altitude**m											
Target distance: 290.75											

**Hide sensitive information such as well numbers and place names

4 Plan Optimization

4.1 Optimization Process

(1) According to information such as drilling footage, well type, well field number, process complexity, and utilization of reserves, etc.
Form a comprehensive evaluation table for deployment scenarios (Table 3);
(2) Select 2 to 3 sets of deployment plans based on the optimal parameter criteria set by the experts in the system (Table 4);
(3) According to wellsite deployment plan format requirements, automatically extract data for statistical analysis and charting and then generate a well location deployment report;
(4) After the manual inspections and revised, the feasibility plan will be approved by the plan. Approved after passing through the management of the library and issued implementation.

4.2 Evaluation of Program Superiority

The program superiority evaluation module is based on the evaluation of production capacity, comprehensive economic benefits, and wellsite safety. It provides sufficient evidence for the optimization of the plan.

(1) Production capacity forecast: It can be used for gas reservoirs of different types and different degrees of exploration and development. It provides a variety of production capacity forecasting methods, such as Arps-declining, Arps-hyperbolic decline, Arps-decay, and Arps-harmonic decrement.
(2) Evaluation of comprehensive benefits: Based on various types of wellsite deployment and construction programs, combined with international gas price and capacity building investment, etc., it can quickly account for the input and output of gas reservoirs, conduct comprehensive economic evaluation, and optimize the most profitable plan.
(3) Wellsite safety evaluation: HSE evaluation was performed on the deployed wellsites for sensitive sources such as villages, farmland, roads, and high-voltage lines, as well as geological disasters, hidden dangers in the project, construction management, and production management.

Finally, we can set important ratios for various factors, perform comprehensive calculation and evaluation, and form 2 to 3 sets of optimal solutions for decision-making personnel to analyze and make decisions.

Table 3. Comprehensive evaluation table for deployment scenarios

Deployment plan	Block	Gas layer	Common area of favorable area	Main well type	Reservoir area	Number of deployed wells	Drilling footage	Process complexity	**
Program 1	**	8	2.5	Straight well	2.5	100	**	Simple	**
Program 2	**	8	2.5	Cluster well	2.7	110	**	Complex	**
Program 3	**	8	2.5	Horizontal well	3.0	50	**	Complex	**
Program 4	**	8	2.5	High inclination well	2.7	110	**	General	**
**	**	**	**	**	**	**	**	**	**

**Hide sensitive information such as well numbers and place names

Table 4. Feasibility plan optimization for well location deployment

Deployment plan	Block	Gas layer	Common area of favorable area	Main well type	Reservoir area	Number of deployed wells	Drilling footage	Process complexity	Preferred
Program 2	**	8	2.5	Cluster well	2.7	110	**	Complex	√
Program 3	**	8	2.5	Horizontal well	3.0	50	**	Complex	√
Program 4	**	8	2.5	High inclination well	2.7	110	**	General	
Program 1	**	8	2.5	Straight well	2.5	100	**	Simple	
**	**	**	**	**	**	**	**	**	**

**Hide sensitive information such as well numbers and place names

5 Summary

At present, the system is undergoing development and trial operation of coalbed methane in Shanxi, and there are many functional modules that need optimization. With the application and continuous improvement in the system, it will definitely bring more and better benefits to our engineering personnel and geologists.

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