

# Quantitative analysis of the influence of mine geological engineering on regional geological environment and research on sustainable development strategy

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**Abstract:** This paper aims to quantitatively analyze the influence of mine geological engineering on regional geological environment, and discuss the application and optimization of sustainable development strategy in this field. This paper first analyzes the main types of mine geological engineering and its influence mechanism on geological environment, then evaluates these influences and discusses the practice and effect of sustainable development strategy in mine geological engineering. This paper puts forward the direction of strategy optimization based on the influence of geological environment, and emphasizes the importance of technological innovation, management mechanism and policies and regulations in strategy optimization.

**Keywords:** Mine geological engineering; Geological environment; Quantitative analysis; Sustainable development strategy; Strategy optimization.

## 1. Introduction

With the rapid growth of global economy, the demand for mineral resources is increasing, and mine geological engineering plays an important role in resource development. However, while promoting economic and social development, such projects will inevitably have a far-reaching impact on the regional geological environment, such as the change of topography, the destruction of water resources and the imbalance of ecological balance. Therefore, it has become an urgent problem to quantitatively evaluate the impact of mine geological engineering on regional geological environment and explore the corresponding sustainable development strategy. This paper aims to provide theoretical support and practical guidance for the sustainable development of mine geological engineering through systematic quantitative analysis and strategic research.

## 2. Analysis of the influence of mine geological engineering on regional geological environment

### 2.1. Main types of mine geological engineering

The main types of mine geological engineering are various, covering many links from resource exploration to mining, processing and abandoned mine management. Among them, open-pit mining is a method of mining ore directly on the surface of the earth, which damages the topography and landforms greatly and easily leads to soil erosion and land degradation. Underground mining, on the other hand, is to enter the underground through shaft and lane engineering to excavate ore. Although it has little impact on the surface, it is easy to cause geological problems such as changes in groundwater level and ground collapse. In addition to the different mining methods, mine geological engineering also involves many links such as ore processing and waste disposal. In the process of ore processing, crushing, grinding, mineral processing and other processes will produce a large number of solid wastes and wastewater, and the unreasonable discharge and treatment of these wastes will cause serious pollution to the surrounding environment. The treatment of abandoned mines is the last link of mine geological engineering, which includes reclamation of abandoned mine land, ecological restoration and prevention of geological disasters. These different types of mine geological

engineering will have different degrees of influence on the regional geological environment in the implementation process. Therefore, in the process of mine development and operation, we must fully consider environmental protection factors and implement sustainable development strategies to reduce the negative effects on the environment.

## **2.2. Mechanism of mine geological engineering's influence on geological environment**

The influence mechanism of mine geological engineering on geological environment is a complex and multidimensional process, which involves many aspects such as crustal stress balance, groundwater dynamic field change, rock mechanical properties change and so on. In the process of mining, large-scale excavation will destroy the original geological structure, lead to stress redistribution, and may lead to geological disasters such as earthquakes and rockbursts. At the same time, mining will also change the direction and distribution of groundwater, destroy the original hydrodynamic balance and have a far-reaching impact on the surrounding environment. In addition, mine geological engineering will also change the mechanical properties of rock mass, leading to the decrease of rock strength and stability, and increase the risk of natural disasters such as landslides and mudslides. These influence mechanisms are interrelated and interact with each other, which together constitute the comprehensive influence of mine geological engineering on regional geological environment. Therefore, in the design and implementation of mine geological engineering, we must fully consider these influencing mechanisms and take scientific and reasonable engineering measures to reduce the damage and negative impact on the geological environment and realize the sustainable development of mining industry. This is not only helpful to protect the ecological environment, but also an important way to realize the coordinated development of economy, society and environment.

## **2.3. Quantitative evaluation method of mine geological engineering impact on geological environment**

The quantitative evaluation method of mine geological engineering to geological environment mainly depends on a series of scientific and rigorous index systems and evaluation models. Firstly, these evaluation methods will consider the ground movement and deformation caused by mining, and make spatial analysis by means of deformation monitoring and settlement observation, combined with geographic information system (GIS) to show the dynamic changes of geological structure with quantitative data. For the problems such as groundwater level change and water pollution caused by mine drainage, hydrology and environmental chemistry methods will be used to carry out water quality detection and water balance analysis, so as to evaluate the impact on groundwater environment. In addition, the accumulation and discharge of mine waste is also the focus of evaluation. By evaluating the volume and composition of waste and its pollution to soil and water, the negative impact on geological environment can be quantitatively analyzed. Comprehensive application of remote sensing technology, numerical simulation and other advanced means to predict and evaluate the risk of geological disasters caused by mine geological engineering, and provide scientific basis for formulating effective sustainable development strategies. These quantitative evaluation methods are not only helpful to deeply understand the actual impact of mine geological engineering on geological environment, but also provide important data support for subsequent environmental governance and ecological restoration.

## **3. The application of sustainable development strategy in mine geological engineering**

### **3.1. The basic concept of sustainable development strategy**

The basic idea of sustainable development strategy emphasizes that the coordinated development of economic benefits, social benefits and environmental benefits must be comprehensively considered in mine geological engineering activities. This concept advocates protecting the stability and ecological balance of geological environment and realizing the sustainable utilization of resources

while developing resources. It requires that in the process of design, construction and operation, mine geological engineering should follow the principles of ecological priority, resource conservation and environmental friendliness, and through scientific planning and technological innovation, reduce the damage to the natural environment, improve resource utilization efficiency, and reduce energy consumption and pollution emissions. At the same time, the sustainable development strategy also pays attention to community participation and communication and cooperation with stakeholders to ensure the harmonious coexistence of mine geological engineering and social and economic development. This basic idea not only conforms to the trend of global environmental protection and sustainable development, but also is an inevitable choice for mine geological engineering to achieve long-term stable development. By implementing this concept, mine geological engineering can be promoted to develop in a greener, low-carbon and circular direction, and make positive contributions to the sustainable development of regional economy and social harmony and stability.

### **3.2. Practice of sustainable development strategy in mine geological engineering**

In mine geological engineering, the practice of sustainable development strategy is very important. In order to achieve this goal, it is necessary to adopt environmentally friendly mining technologies and methods. For example, filling mining method can not only reduce the risk of surface collapse, but also effectively use resources by filling goaf with waste. At the same time, the implementation of green mining can reduce the damage to the geological environment by reducing wastewater discharge and improving resource recovery rate. In addition, it is necessary to pay attention to the protection and management of mine geological environment. The establishment of mine geological environment monitoring system, real-time monitoring of the impact of mining on the geological environment, timely find and solve problems. Strengthen the ecological restoration of mine wasteland, and promote the restoration and stability of the ecosystem through measures such as vegetation restoration and soil improvement. In mine geological engineering, we should also pay attention to the rational utilization and recycling of resources. By improving the efficiency of resource utilization, reducing the waste of resources and realizing the sustainable utilization of resources. At the same time, promote the recycling of waste, turn waste into resources and further reduce the impact on the environment. In a word, the practice of sustainable development strategy in mine geological engineering needs to start from many aspects, including adopting environment-friendly technology, strengthening environmental protection and governance, and rationally utilizing and recycling resources. The implementation of these measures will help to realize the sustainable development of mine geological engineering and promote the coordinated development of economy, society and environment.

### **3.3. Evaluation of the effect of sustainable development strategy in mine geological engineering**

It is a complex and critical process to evaluate the effect of implementing sustainable development strategy in mine geological engineering. It involves comprehensive consideration of geological environment impact, resource utilization efficiency, economic benefit and social impact. By using advanced monitoring technology and data analysis methods, we can quantitatively evaluate the implementation effect of these strategies. In terms of geological environment, we pay attention to key indicators such as soil remediation, water body protection and terrain stability, and evaluate the changes of these indicators before and after the implementation of the strategy, so as to judge whether the sustainable development strategy effectively reduces the negative impact of mine geological engineering on the environment. In terms of resource utilization, we analyze the data of resource recovery rate, energy consumption and waste generation, and evaluate whether the strategy improves the efficiency of resource utilization and promotes the development of circular economy. At the same time, we should also consider the economic benefits, analyze the cost changes, profit growth and market competitiveness of enterprises after the implementation of the strategy, so as to judge whether the strategy is economically feasible. In terms of social impact, we pay attention to the quality of life, employment situation and social harmony and stability of local residents, and evaluate whether the strategy has been widely recognized and supported by society. Through the comprehensive evaluation

of these aspects, we can fully understand the implementation effect of sustainable development strategy in mine geological engineering and provide scientific basis for future strategy formulation and adjustment.

#### **4. Mine geological engineering sustainable development strategy optimization suggestions**

##### **4.1. Strategic optimization direction based on geological environment impact**

In the optimization direction of the sustainable development strategy of mine geological engineering, our primary consideration is the comprehensive evaluation of geological environmental impact. This requires us to have a deep understanding of the influence of mining activities on geological structure, hydrological conditions, soil quality and ecosystem. By using geological environment monitoring technology, such as geographic information system (GIS) and remote sensing technology, the dynamic monitoring of mine geological environment can be realized, and then the environmental impact of different mining schemes can be accurately evaluated. On this basis, strategy optimization should focus on reducing negative environmental impact and promoting ecological balance. For example, by optimizing the mining layout, the risk of surface collapse and groundwater table decline can be reduced; Through the implementation of resource recovery and reuse measures, improve resource utilization efficiency and reduce environmental load; By popularizing green mining technology, such as filling mining method, the generation and discharge of mine waste can be reduced. At the same time, we need to pay attention to the protection and restoration of geological environment and establish a long-term mechanism. This includes the formulation of strict environmental protection standards, the implementation of mine environmental control projects, and the establishment of environmental restoration funds. Through these measures, we aim to realize the sustainable development of mine geological engineering and provide a strong guarantee for the long-term prosperity of regional economy and the harmonious symbiosis of ecological environment.

##### **4.2. The role of technological innovation and management mechanism in strategy optimization**

In the process of optimizing the sustainable development strategy of mine geological engineering, the role of technological innovation and management mechanism can not be ignored. Technological innovation is the core driving force to promote the development of mine geological engineering. By introducing advanced mining technology, resource utilization technology and environmental treatment technology, the damage to the geological environment can be effectively reduced, the resource utilization efficiency can be improved, and the energy consumption and emissions in the production process can be reduced. For example, the application of intelligent mining technology can realize accurate mining of mineral resources and reduce waste; The green treatment technology can repair the damaged environment and promote ecological balance after the project is completed. Management mechanism plays a guiding and guaranteeing role in strategy optimization. Establishing a sound management mechanism can not only ensure the effective implementation of technological innovation, but also standardize the production activities of mine geological engineering and prevent over-exploitation of resources and environmental abuse. By formulating strict environmental protection standards, safety production standards and resource utilization standards, enterprises can consciously adopt more environmentally friendly and efficient production methods and promote the sustainable development of the whole industry. Therefore, technological innovation and management mechanism play a vital role in the optimization of sustainable development strategy of mine geological engineering. They promote each other and depend on each other, which together constitute a powerful driving force to promote the development of mine geological engineering in a green, efficient and safe direction.

### **4.3. Policies and regulations support and guide the strategy optimization**

Policies and regulations play a vital role in the optimization of sustainable development strategy of mine geological engineering. By formulating and perfecting relevant laws and regulations, the government can provide strong support and guidance for the sustainable development of mine geological engineering. These policies and regulations should not only pay attention to environmental protection and resource utilization, but also promote technological innovation and industrial upgrading. At the policy level, the government can introduce a series of incentive policies, such as tax incentives and financial support, to encourage mining enterprises to adopt more environmentally friendly and sustainable production methods. At the same time, through the formulation of strict environmental protection standards and supervision system, mining enterprises can be promoted to strengthen environmental governance and ecological restoration, and reduce the negative impact on the regional geological environment. In terms of laws and regulations, the government should improve the legal system of mine geological environment protection, clarify the legal responsibilities and obligations of mining enterprises, and strengthen the punishment for illegal acts. In addition, the monitoring and evaluation mechanism of mine geological environment should be established and improved, and the mine geological environment should be evaluated and monitored regularly to ensure the sustainable development of mine geological engineering. In a word, the support and guidance of policies and regulations is very important for the optimization of sustainable development strategy of mine geological engineering. By formulating and perfecting relevant policies and regulations, the government can promote the green development, transformation and upgrading of mining enterprises and contribute to the protection and sustainable development of regional geological environment.

## **5. Summary**

The aim of this paper is to examine the quantitative impact of mine geological engineering on the regional geological environment and propose corresponding sustainable development strategies. By conducting a thorough analysis of the primary types of mine geological engineering and their mechanisms of influence on the geological environment, this study establishes a quantitative evaluation methodology, providing a scientific foundation for strategy formulation.

Mine geological engineering encompasses various activities that can significantly alter the geological landscape and impact the surrounding environment. Understanding the diverse types of mine engineering, such as excavation, drilling, and waste disposal, is essential for comprehending their implications on the geological environment. Through a detailed investigation of these activities and their associated environmental effects, this paper aims to quantify the extent of their impact using established evaluation methods. Furthermore, this paper delves into the practical implementation and application of sustainable development strategies in the context of mine geological engineering. By evaluating the effectiveness of these strategies, the study seeks to identify successful approaches and areas for improvement. Sustainable development strategies aim to mitigate the adverse effects of mine engineering activities on the environment while fostering long-term ecological balance and societal well-being. Drawing from the analysis of geological environmental influences, this paper offers recommendations for optimizing sustainable development strategies. Emphasizing the crucial role of technological innovation, effective management mechanisms, and supportive policies and regulations, the study advocates for holistic approaches that address both environmental conservation and economic development imperatives.

Technological innovation plays a pivotal role in enhancing the sustainability of mine geological engineering practices. Advancements in mining technologies, such as environmentally friendly extraction methods and efficient waste management techniques, can minimize environmental degradation while maximizing resource utilization. Additionally, investing in research and development initiatives aimed at reducing the ecological footprint of mining operations is essential for achieving sustainable outcomes. Effective management mechanisms are essential for ensuring the

responsible and ethical conduct of mine geological engineering activities. Implementing robust monitoring and compliance protocols can help mitigate environmental risks and ensure regulatory compliance. Furthermore, fostering stakeholder engagement and promoting transparency in decision-making processes are vital for building trust and fostering collaboration within the mining community.

Policies and regulations play a pivotal role in shaping the trajectory of mine geological engineering practices. By enacting legislation that prioritizes environmental protection and sustainable development, governments can create a conducive regulatory environment that incentivizes responsible mining practices. Additionally, providing financial incentives and tax breaks for companies that adopt environmentally friendly technologies can encourage widespread adoption of sustainable practices. In conclusion, this paper underscores the importance of addressing the quantitative impact of mine geological engineering on the regional geological environment through the implementation of sustainable development strategies. By adopting a holistic approach that encompasses technological innovation, effective management mechanisms, and supportive policies and regulations, the mining industry can promote environmentally responsible practices and contribute to the long-term well-being of both ecosystems and communities.

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