An Analysis of Progress and Models of Local Green Mining

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Abstract. The development of green mining is an important measure to improve the ecological civilization construction in the mining field and build a beautiful China. On the basis of extensive research, the author analyzes the development progress of green mining in China from 7 aspects. Based on the unique practical experience of various regions, the author summarizes four development models, namely: multi-industry integration development model, integrated development model of mining, processing, manufacturing and transaction, comprehensive development and utilization mode of mine and land, and layout optimization driving model, and analyzes the problems faced by green mining in three aspects: technological innovation, working mechanism, and system construction. Based on this, countermeasures and suggestions are proposed: the first is to promote technological innovation, develop and promote new efficient technologies in the development and utilization of mineral resources; the second is to promote management innovation and establish a new working mechanism for green mining; the third is to promote institutional innovation and effectively play the guiding role of policies.

1. Background
Since General Secretary Xi Jinping proposed that "it is necessary to achieve economic development as well as environmental protection", all walks of life have paid more attention to green development. The "Thirteenth Five-Year Plan for National Economic and Social Development", "Thirteenth Five-Year Plan for National Land and Resources" and "National Mineral Resources Plan (2016-2020)" have all deployed the construction assignment of green mining development. Six ministries and commissions such as the Ministry of Land and Resources and Ministry of Finance have jointly issued the "Implementation Opinions on Accelerating the Construction of Green Mines" (Ministry of Land and Resources [2017] No. 4), proposing to establish a model of thousands of green mines and build more than 50 green mining development areas by 2020, which has formed a batch of new models, new mechanisms, and new systems that can be replicated and promoted. Local governments have been actively engaged in the exploration and practice. Based on the strategic positioning of green operation of mines, green development of the industry and green management of the government [1], local governments have organized and promoted the green development of mining industry, promoted the innovation of technological system, standard system, industrial model, management method and policy.
mechanism, thus forming a batch of typical models of green mining development that can be replicated and promoted.

2. **Practice Progress**

2.1. **Standardizing Management and Building a Long-Term Mechanism for Green Development**

In order to ensure the steady progress of the development and construction of green mining, the municipal and county people’s governments have established a work leadership group in some areas, specifically clarifying members in the leadership group. Also, offices and funds for special activities have been established under the leadership group, and members from National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Finance, Environmental Protection Administration, State Administration of Work Safety, Forestry Bureau, Ministry of Agriculture, Water Supplies Bureau, Tourist Administration, Ministry of Communications and Ministry of Housing and Urban-Rural Development are included. The leading group is responsible for leading, organizing, planning and coordinating the construction work, and the division of responsibilities is clarified. In terms of management, the policy system, standard system, work system, supervision system, and benefit-sharing system are innovated to promote the establishment and development of the new mechanism of green mining.

2.2. **Optimizing the Survey and Development Layout Based on the Principle of Plan Implementation and Strict Access**

It is necessary to strictly implement the plan for mineral resources and related development in the "Thirteenth Five-Year Plan", and follow the principle of ecological priority, total volume compression and strict management of mineral resources according to law. The access management of development and utilization should be strictly controlled and the zoning management system should be implemented. The mining right should be set in a rational way, and the package exploration and mine layout optimization should be promoted. The concentration of mining should be enhanced, and the large-scale, intensive and base development of mines should be promoted. In accordance with the principle of "respecting history and being safe and orderly", the exploration right in nature reserves shall be handled in accordance with laws and regulations and classified in a classified way. In the end, the exploration in nature reserves shall withdraw gradually. For example, Yichang, Hubei has highlighted the planning guidance, total control, and zoning layout, compiled the "Development Plan of "China's Ecological Phosphorus Capital "of Yuan'an County (2014-2030)", and implemented the "dual control" of the total quantity and mining right of phosphorus.

2.3. **Promoting Industrial Structure Adjustment Based on Resource Integration, Industrial Chain Extension and Transformation**

By clearing the exploration right and integrating mining right, the concentration of resources to advantageous enterprises and the large-scale development and intensive use of mineral resources can be promoted. Also, the integration of complementary advantages among enterprises can be completed through capital, technology, resources and products. The industrial chain shall be extended and the transformation of product structure from primary products to deep-processed products shall be accelerated. It is also necessary to promote the high-end and terminal development of the industry, build a deep-processing base and encourage and guide the transformation of mining enterprises into big data, electronic information, equipment manufacturing, energy conservation and environmental protection, cultural tourism industry, health care industry, new energy, ecological agriculture, and green food processing industry. For example, Jinchang, Gansu has further enhanced the large-scale utilization of low-grade copper-nickel sulfide mines, and built a number of demonstration projects for comprehensive utilization of comprehensive utilization of solid waste and extension of the industrial chain. The Tieshan District of Hubei has restored the management of closed mines and promoted the transformation to tourism and other related industries, achieving the regional economic development.
2.4. Comprehensively Promote Green Exploration Based on Ideas, Systems, Standards and Projects

The concept of green exploration must be established to minimize the impact on the environment during the entire process of geological exploration and repair the disturbed ecological environment. The green exploration technique, process and method suitable for environmental protection should be actively studied and promoted, and the damage to surface vegetation should be reduced. It is necessary to gradually establish a green exploration technology system, establish and improve a green exploration standard system. The institutional system including guiding opinion, implementation scheme and supervision for green exploration should be explored and formulated to improve the management system. For example, Guizhou has officially released the local standard of "Technical Specifications for Green Exploration of Solid Mineral Resources".

2.5. Technological Innovation, Tailings Utilization, Clean Production and Improving the Comprehensive Utilization of Resources

It is necessary to encourage mining enterprises to transform and upgrade the mining technology, promote the use of new processes, new technologies, and new equipment, and adopt advanced and safe mining techniques and mining methods, thus enabling the mining recovery rate and comprehensive recovery utilization rate of the main minerals and associated minerals to meet or exceed the design requirements. At the same time, the research on the comprehensive recycling of tailings should be strengthened to develop and utilize tailing resources (waste rocks), gradually reduce the stock of tailing resources, and take protective measures for associated minerals that are not exploited. It is necessary to promote clean production, develop and apply pollution-free and less-pollution purification and deep-processing technology to reduce waste emissions. For example, the northern part of Luobei County in Heilongjiang focuses on the production of high-purity graphite with carbon content of 99.9% and above 99.99%, and establishes graphite purification and deep-processing projects.

2.6. Implementing Entity Responsibility, Strengthening Management and Comprehensive Control, and Strengthening the Protection and Management of Geological Environmental

The entity responsibility of enterprises in protection and management should be clarified, and the geological environment problems caused by mining activities should be addressed in a timely manner. The entity responsibility of government for the restoration and management of the lost mineral resources should be clarified, and government needs to arrange special funds to gradually carry out the restoration and management of the geological environment of mines. The integrated development of mine environment management and land development, tourism, pension, breeding, planting and other industries can be explored to achieve a win-win situation for mine environmental management and industrial development, environmental protection, and ecological restoration. For example, Yumen, Gansu integrates the responsibility of mine environmental protection and management into the entire life cycle of mineral development.

2.7. Benefit Sharing, Deliberation and Coordination, and Promoting the Harmonious Development between Land and Mines

It is necessary to innovate the new path for resources to benefit the people, combine the development of green mining with the "village revitalization" strategy and "precision poverty alleviation" and closely combine mining and agriculture, mines and rural areas, miners and farmers, so that the government, enterprises and people in mining areas can share the benefits from resource development and development achievements. The deliberation and coordination mechanism for local government, representatives of the masses and enterprises should be established and the institution and personnel responsible for the investigation and coordination of conflicts in the mining area should be clearly defined to deal with issues such as ecological environmental protection, migration relocation, land acquisition compensation, and transportation in a timely manner and properly resolve various conflicts. For example, Peixian, Jiangsu explores the innovative mode of "mining farms", combining the
exploration of underground coal resources with the reclamation of coal mining subsidence areas and village relocation to form a “community of shared interest” in mining areas.

3. Development Model

China has a vast territory, which leads great differences in the natural geographical and ecological conditions, economic and social development, development and utilization of mining resources, and mining economic development status. In this way, the form of green mining development in China is diversified [2]. According to different development environments and characteristics, the following four modes are summarized.

3.1. Multi-Industry Integration Development Model

3.1.1. Characteristics. The multi-industry integration development model refers to adhering to the concept of green transformation, encouraging and guiding mining enterprises to transform into big data, electronic information, equipment manufacturing, energy conservation and environmental protection, cultural tourism, pension care service, new energy, ecological agriculture, and green food processing industries. It is necessary to strive to create new areas of economic growth and to achieve the transformation and upgrading and green development of the mining industry. In areas with high level of economic development, gradual depletion of mineral resources, or important ecological and environmental protection areas, emphasis is mainly placed on industrial transformation and development mode.

3.1.2. Case. There are many types of minerals in Chengde, Hebei, and the total amount of resources and potential value are huge. However, there are few high-quality mines and large and small number of large and medium-sized mines. Subject to the market environment, the normal productivity of mines is low. Chengde encourages and guides mining enterprises to transform into electronic information, equipment manufacturing, energy conservation and environmental protection, cultural tourism, and green food processing industries, especially encouraging and guiding mining enterprises to invest in emerging industries such as mineral water and mountain spring water. Also, large and medium-sized mining enterprises are encouraged to participate in the construction, operation and management of mine geoparks, and actively explore the integrated development of mine environment management and land development, tourism, pension, breeding, planting and other industries, so as to achieve a win-win situation for mine environment management and industrial development, environmental protection, and ecological restoration.

3.2. Integrated Development Model of Mining, Processing, Manufacturing and Transaction

3.2.1. Characteristics. The integrated development mode of mining, processing, manufacturing and transaction refers to optimizing the industrial layout, integrating resources and centralized mining, guiding the mineral processing industry into the industrial park, and promoting the scale and agglomerational development of processing industry. The comprehensive utilization of tailings should be emphasized, and research on the reprocessing and utilization of tailings and the extension of industrial chain technology should be carried out. The productive service industry should be developed vigorously and it is important to establish the development model of regional industrial clusters that integrates mining, product processing, commerce display, and supporting services, with a reasonable layout, professional cooperation, environmental friendliness, and sound industrial chain.

3.2.2. Case. The development of stone industry in Suixian County, Hubei is of scale advantages, whose reserve of granite and feldspar resources for decorative use ranks the first in the province. It is an important stone material industry base in China. Relying on the advantage of stone resources, Suixian County has vigorously extended the industrial chain, strengthened the recycling of solid waste in mines,
accelerated the resource utilization of solid waste such as crushed stones, stone powder, and built a circular economy industrial park of stone industry in Suixian County. The aim is to build this park into a regional green mining industry cluster that integrates mining, product processing, commerce display, and sound industrial chain, and the most influential modern stone industry demonstration park in the central region.

3.3. Comprehensive Development and Utilization Mode of Mines

3.3.1. Characteristics. The comprehensive development and utilization mode of mines refers to the coordinated development and utilization mode of resources carried out by the mining-right owner of opencast mines for the unified planning, comprehensive development and efficient utilization of mineral resources within the mine filed and the land resources after mining. Regarding the opencast mine, it is necessary to strengthen the interaction with relevant planning, reasonably determine various construction layouts and scales in the pilot mining area, and do a good job in the site selection of mining rights based on the planning of mineral resources. It is important to ensure that construction land can be generated after mining, clarify the utilizing direction, and promote subsequent industrial development, including rural revitalization strategy, new urbanization construction, tourism development, green industry, comprehensive agricultural development, construction of major infrastructure and public service facilities.

3.3.2. Case. The non-metallic mineral resources for building materials in Huzhou, Zhejiang are relatively abundant, and the main minerals for development and utilization are construction stone and limestone. Based on the development and utilization characteristics of mineral resources, Huzhou has promoted the new mechanism of mineral land integration, and explored the integrated development of mineral resources and land resources. Also, Huzhou has carried out the demonstration project for the integrated development of mine and land and organically unified the development and utilization of resources, comprehensive utilization of mining and land, and ecological environmental protection of mines. Through pilot work on the reclamation of abandoned industrial and mining sites, the demonstration project for the management of abandoned mines is created, which combines the rehabilitation of abandoned mines, land reclamation, village rehabilitation, new rural construction, development of tourism resources, and landscape construction, eliminating the potential safety hazard of mining slope, improving the ecological environment, and realizing three major benefits of ecology, safety and land as well.

3.4. Layout Optimization Driving Mode

3.4.1. Characteristics. According to the third round of mineral resources planning, the layout optimized driving mode refers to, dividing key mineral exploration and development areas into depletion area (restricted development area), development area (key development area), and prospect area (resource reserve area) in areas with obvious advantages and high concentration of special mineral resources based on the distribution characteristics of mineral resources, current situation of exploration and development, and resources environment carrying capacity and combined with the layout of national economic and social development. In this way, partitioned management can be performed and mines in depletion areas will gradually withdraw so as to provide the docking index of mining rights for development areas and promote the restoration and management of the geological environment of mines; it is necessary to strengthen the management in development areas and vigorously promote the construction of green mines; in prospect areas, it is necessary to fully promotes the concept of green exploration and strengthen the protection of geological environment. The ecological exploitation of advantageous minerals is used as a typical demonstration to drive the green development of all minerals in the whole region and the extension of the related industrial chain.
3.4.2. Case. The Baokang County is rich in mineral resources, whose number of proved reserves reaches 32, of which the prospective reserves of phosphate rock resources exceed 2 billion tons. Based on optimizing the layout of the phosphate industry, Baokang County has vigorously promoted the green development of phosphate mines. It is planned to delineate areas with specific principal functions according to the development potential of phosphate mines and the resources environment carrying capacity in different regions. 13 phosphate mining areas are divided into three main functional areas, namely, "depletion area", "development area", "potential area": in "depletion area", emphasis should be placed on creating tourism products; in "development area", the emphasis is to improve the technical level in each link of the development and utilization of phosphate; the "potential areas" is taken as the succession development area of phosphate in Baokang. At the same time, the phosphorus industry can drive the coordinated development of other related industries.

4. Problems in Green Mining Development

4.1. Technological Innovation and Independent Innovation Need to Be Strengthened
Some regions have not attached much significance to technological innovation, resulting in relatively backward production technology and equipment and low degree of deep processing and comprehensive utilization of resources. The long-term resources mining industry and its derivative industries in some regions involve more primary products and fewer terminal products. The extensive economic growth mode with low technological content has not been fundamentally changed, posing severe challenges to transformation and sustainable development.

4.2. Working Mechanism Needs to Be Improved
The green mining development is a systematic project involving many departments and industries including Ministry of Land and Resources, Environmental Protection Administration, Bureau of Water Resources, Forestry Bureau, Ministry of Finance, and State Administration of Work Safety and it is necessary to further define specific responsibilities in terms of organization and coordination, task promotion, supervision and inspection. The management organization should further strengthen the leadership and coordination in practice [3]. In some areas, due to unclear development ideas of green mining, weak leadership and innovation capability, inadequate combination between main tasks and local realities, and lack of planning and overall cooperation among various departments, the overall advantage has not been brought into full play.

4.3. Institutional Construction Needs to Be Strengthened
The construction of green mines is an all-round and comprehensive work and mining enterprises have huge investment in intelligent management, resource utilization, environmental protection, cultural construction, and social responsibility. However, existing policies have limited encouragement effect. The No.4 Document has clearly indicated the direction for preferential policies in mine, land, taxation and finance, but some regions have not formulated the operating method according to specific local conditions, so it is difficult for mining enterprises to enjoy the policy support. For example, the existing policy proposes to levy an 85% tax rate on the corporate income tax of high-tech industries and enterprises in west China have already enjoyed this tax relief.

5. Suggestions for Promoting the Green Development of Mining Industry

5.1. Promoting technological innovation and R&D in efficient and new technologies for the exploitation and utilization of mineral resources
The mining technology should be renovated and upgraded with the concept of innovation and transformation. The first is to actively explore green exploration methods, learn new technologies, new methods, and new processes, innovate resources exploration and development modes, and reduce the damage to the ecological environment. The second is to guide enterprises to adopt advanced and
applicable technologies, improve the level of mining, reduce pollutant emissions, give full play to the main role of mining enterprises in technological innovation, encourage the cooperation between scientific research institutions and enterprises, carry out the R&D, promotion and application of new technologies, and strengthen the R&D in mineral processing equipment and technology of refractory mines and complex associated mines [4]. The third is to strengthen the recycling of tailings and waste rocks, adopt processing technologies and solutions that combine processing and landfill and improve the comprehensive utilization rate of solid waste.

5.2. Promote Management Innovation and Establishing a New Working Mechanism for Green Mining

From the perspective of the overall planning of mineral resources management, industry access, monitoring and supervision, and coordination of mine and land, it is necessary to explore a set of long-term mining administration management mechanisms for the development and operation of green mining industry that meet the requirements of Scientific Outlook on Development and ecological civilization construction, and suit the law of market economy. The first is to clarify the division of responsibilities and make a "combination blow." Governments at all levels should assume the main responsibility of local green mining development. Also, departments including Ministry of Land and Resources, State Administration of Work Safety, Environmental Protection Administration, Public Security Bureau, Forestry Bureau, Bureau of Water Resources, Ministry of Finance, and Electricity Bureau should fulfill their responsibilities, and the construction situation should be regarded as an important content of the performance evaluation of cadres. The second is to establish a comprehensive supervision mechanism in the mining field, implement territorial management responsibilities, strengthen the main responsibility of People's Government of a county, city and district for mineral resources management, establish and improve the joint responsibility body and long-term mechanism for law enforcement supervision of government and departments, joint law enforcement of townships, and coordinated supervision.

5.3. Promoting Institutional Innovation and Giving Play to the Guiding Role of Policies

On the basis of existing laws, regulations, rules and policies, rules and measures that are conducive to the development of green mining should be formulated and the macro-control role of the government in resource development and environmental protection should be strengthened. The first is to formulate policies and plans to support the green mining development in accordance with local conditions, effectively provide a good policy environment for the green mining development, supervise and inspect the implementation of various policies and measures, and track and evaluate the effectiveness of policy implementation. The second is to explore establish the incentive and restraint mechanism suitable for the actual conservation and comprehensive utilization of mineral resources, and establish the promotion mechanism for the comprehensive utilization of advanced technologies suitable for the market economy. The third is to innovate new policies for the integration of mineral resource management and land resource management, and promote the integrated development of mineral resource development and land use.

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