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RESEARCH ARTICLE

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Relationship between the development of energy and mineral resources and ecological conservation redline

Abstract From a philosophical point of view, this study discusses the dialectical relationship between the development of energy and mineral resources and the ecological conservation redline. We propose that the ecological conservation redline and the development of energy and mineral resources should be guided by ecological civilization construction, that is, the energy and mineral resources should be rationally developed under the condition that the ecological environment is protected. This study analyzes the influence of the development of energy and mineral resources on the ecological environment. The handling of mining rights within the ecological conservation redline based on the law and the reduction of the influence of the development of energy mineral resources on the ecological environment by science and technology are presented. The environmental assessment system and technical standards for energy and mineral development are suggested to implement policies and measures for the disposal of mining rights within the redline and facilitate technological innovations of ecological conservation for energy and mineral development. Hence, a coordinated development between the ecological conservation redline and the development of energy and mineral resources can be promoted.

Keywords ecological conservation redline, development of energy and mineral resources, coordinated development

1 Introduction

The Chinese government has emphasized that the ecological conservation redline must be guarded, and the concept of ecological conservation must be firmly established. Delimiting and strictly following the ecological conservation redline are the strategic policies made by the Party Central Committee and State Council for constructing ecological civilization on the basis of being responsible to history and the people. The ecological conservation redline is an important new measure in the new historical era that includes many aspects, especially in the areas of energy and mineral development. Therefore, addressing the relationship between the development of energy and mineral resources and the ecological conservation redline is important in promoting the construction of ecological civilization and ensuring the supply of national energy and mineral resources.

2 Understanding the relationship dialectically

The ecological conservation redline is a delimited area of ecological space that bears important ecological functions and deserves strict protection. The redline is the bottom line and lifeline for the protection and maintenance of national ecological security. In principle, the areas in the ecological conservation redline is managed by prohibiting the development of mineral resources and barring any type of exploration and development activities that violate the subject functional orientation. Once the ecological conservation redline is defined, it can only be increased and not decreased. In the case of national strategic material needs, the exploration projects should be arranged after approval by the law under the condition that no influence will occur on the subject functional orientation. The essence of the ecological conservation redline is a replanning and reorientation of the utilization of all types of natural resources in the ecological space on the basis of the evaluation of environmental and resource capacities and the suitability of land and space development. The exploration and development activities of energy and mineral resources, as important parts of ecological space, will inevitably affect the ecological environment (He,

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Energy and minerals, which are important natural resources in the ecological space owned by the nation, are the foundation of economic and social development. To build a comprehensively modernized society and achieve the ultimate goal of "two hundred years", the supply of energy and mineral resources must be sufficient. The exploration and development of energy and mineral resources, especially the overexploitation of resources or unreasonable exploration and development, will inevitably affect the ecological environment and lead to excessive environmental load, insufficient ecological carrying capacity, environmental pollution, and ecological deterioration (Hu, 2013; Wilson, 2014). The main risks and influencing factors are presented as follows:

(1) Oil and gas exploration and development. The wastewater produced in the drilling process, waste mud, back liquid, and cuttings, may pollute surface water. Moreover, the recharge of a large amount of oily wastewater has a remarkable influence on groundwater. The influence on the atmosphere mainly comes from diesel engines used in construction, the smoke produced by the diesel generator during operation, and air pollution. The effects of solid waste on soil are mainly from the drilling waste mud, drilling cuttings, construction waste, and domestic garbage. The effect on vegetation is mainly from the destruction of vegetation by land occupation. Other environmental effects are caused by the noise generated by vehicles and mechanical constructions, such as generated during drilling, transportation, trench excavation and backfilling in leveling site, and building construction (Li and Liu, 2009; Wang, 2012).

(2) Exploration and development of solid minerals. The main causes are surface vegetation damage, soil erosion, desertification, land cracking, subsidence, collapse, landslide, debris flow, and other geological disasters resulting from mineral exploration and development. Waste residue, wastewater, and waste gas would pollute water, soil, and air, destroy wildlife and natural geological landscape, endanger the health of human beings, and damage properties. The analysis of the main minerals show that coal mining can easily cause surface subsidence, cracks, mountain slide or debris flow, dropping of the underground water level in the mining area, and gas emission. The surface environment and vegetation are destroyed by the large amount of waste rock or small amount of wastewater, bauxite, and rare-earth minerals produced during nonferrous metal mining. Copper mines may produce acid wastewater, and lead–zinc mines may produce water with heavy metals, which may cause river and water pollution. Cyanidation of gold is often used in production, which usually generates cyanide residue, cyanide wastewater, dust, sulfur dioxide, nitrogen oxide, cyanide flue gas, and other pollutants. Opencast stope of building materials results in unstable slope and unbalanced ground pressure, leading to dangerous rock caving and landslides (Cao, 2018).

Certain risks and influencing factors are caused by human disturbance and others existing in nature, but most of them are controllable. Energy and mining development has advantages and disadvantages. On the one hand, this important engineering method is a way of providing energy and mineral materials; on the other hand, it interferes with the ecological environment. Understanding and handling of the dialectical relationship between the two aspects can promote, control, coordinate, and balance each of them and then achieve harmonious development.

From a philosophical point of view, a contradictory but dialectical relationship exists between the development of energy and mineral resources and the ecological conservation. On the one hand, both sides are dynamically unified in certain social and historical stages of development. However, in different stages, different requirements, standards, and engineering techniques exist for the protection of the ecological environment and energy and mineral development. On the other hand, the contradicting sides can change under certain historical conditions, namely, the main and secondary aspects of such contradiction can change each other. This change depends on the subjective initiative of humans. The implementation of the development of energy and mineral resources roughly changes the original state of nature. First, "change" can destroy ecosystems and harm human survival and development. Second, "change" allows the ecosystems to adapt to the healthy evolution, which is beneficial to human development. The reasonable development of energy and mineral resources for protecting the ecological environment is an active and positive protection, but not a static and isolated one.

In practice, two balances are required to achieve the active and positive unification of the development of energy and mineral resources and the ecological conservation redline. The first is between the consumption of the ecological environment and the profits from the development of energy and mineral resources. The second is between the mining development and the bearing capacity and recovery capability of the ecosystem. With these two balances, the development of energy and mineral resources and ecological and environmental protection will be dialectically and dynamically unified. Hence, we must prioritize ecological and environmental protection, protect in development, and develop in protection. This finding is a profound revelation of the relationship between the development of energy and mineral resources and ecological protection. Therefore, in the delineation of the ecological conservation redline, we should consider "development at the point" and "protection on the area". "Development at the point" refers to setting up the strictest entry threshold and most advanced environmental protection concepts and management methods, inviting the best professional teams, and using a technical equipment in

performing the development of energy and mineral resources. "Development at the point" not only provides energy resource and minerals for economic development, but also builds the foundations and financial support for the protection of the ecological environment, thus promoting the "protection on the area". This coordinated development of energy and mineral resources and ecological conservation is finally achieved in a win-win situation (Hu et al., 2012; Zhang, 2019a).

3 Handling the relationship scientifically

The construction of ecological civilization is closely connected to the well-being of the people and the future of the nation in the long-term. The construction of ecological civilization should lead to the determination of the ecological conservation redline and the development of energy and mineral resources. Under the condition that the ecological environment is protected with priority, we can rationally arrange the development of energy and mineral resources and scientifically handle the relationship between these two aspects, in accordance with the law to achieve the coordinated development of ecological conservation and the development of energy and mineral resources.

3.1 Promotion of lawful mining right within the ecological protection redline

The development of energy and mineral resources is implemented within the scope of lawful mining rights. At present, the large area within the ecological conservation redline overlaps with the important metallogenic belt and oil and gas blocks. When we delimit the ecological conservation redline and the withdrawal of mining rights, we should focus on the future and coordinate with the national ecological security and safety of resources, build a good layout of the national strategic energy and mineral replacement, designate the resource-replacement bases in the important metallogenic belt or oil and gas prospective areas, allow basic geological work within the ecological conservation redline, and increase investment. As such, the needs of strategic reserves for energy and mineral resources can be met (Li et al., 2019a).

However, classifying and managing different minerals are necessary. Special protection for oil and gas, coal, rare-earth, iron, copper, aluminum, tungsten, uranium, and other important strategic minerals shall be implemented, and the development of these minerals must be examined and approved by the State Council. For the overlapping areas with strong environment-bearing capacity, the exploration and development process should be accelerated under the condition that technical standards of environmental protection are improved. The aim is to realize the harmonious coexistence of utilization of resources, economic development, and ecological environmental protection. In protected areas with fragile environmental bearing capacity, exploration and development activities should be withdrawn in an orderly manner to meet the need of the conservation redline. Moreover, the discovered resources should be registered as national strategic reserves. For the mining rights that withdraw voluntarily from the conservation areas, deductions on exploration rights should be allowed (Xu et al., 2018).

Additional measures should be taken and the problem brought by the withdrawal of mining rights should be fully considered to promote the ecological conservation redline properly and withdraw the mining rights orderly. Referring to relevant international experience, the lawful mining rights that existed before the redline of ecological protection were delineated, thereby following the non-retroactivity principles of the law and protection of property rights, existing mining rights are recognized and new mining activities are prohibited, in order to gradually withdraw from the redline area when the mining right expires. For the mining rights examined and approved after the establishment of the redline area, the guidance for classified disposal shall be established, whereas a transitional period of 3–5 years should be set aside for its complete withdrawal to ensure that strict standards of safety and environmental protection are followed. For small mines, the implementation of "compensation and then withdrawal" should be executed. That is, the government contributes to the compensation cost, the enterprises address the placement of workers, the mine pits and environmental control are closed, and environmental management deposits are returned to ensure a smooth and orderly exit (Zhang, 2013).

3.2 Reduction of the influence of energy and mineral development on the ecological environment by relying on technology

Defining the redline of ecological protection requires the consideration of basic national conditions, such as resource endowment, environmental capacity, and ecological condition, rationally setting the redline control, construction of a redline control system, establishment of the redline management and control system, improvement of the development quality and efficiency, and construction of a new pattern for the harmonious development between man and nature. This approach promotes high requirements on the development of energy and mineral resource technology, cost control, and environmental protection. In recent years, with the continuously increasing ecological and environmental requirements, the relationship between the development of energy and mineral resources and the ecological protection redline has been scientifically and dialectically solved in the practice of the development of energy and mineral resources by strengthening the concept of ecological and environmental protection, relying on

advanced science and technology and green mining, and using green technology of environmental protection (Zhang, 2019b).

In this study, we will use the development of energy and mineral resources of oil and gas, coal, and solid mineral resources as examples to address this issue (Du and Zhang, 2019).

3.2.1 Innovation and integration of green technology of environmental protection for oil and gas exploration and development

We use the Fuling shale gas field of Sinopec as an example. During exploration and development, the green development technologies for shale gas have been formed on the basis of the "cost saving and environment friendly" industry chain, which leads to green environmental protection and development.

(1) Importance of land and ecological protection. We need to optimize the site selection to avoid ecologically sensitive areas and reduce vegetation damage as much as possible. We should persist in saving land through reducing land usage and carrying out vegetation restoration in accordance with the reclamation scheme by means of cluster wells and well factory modes.

(2) Water pollution prevention, control, and recycling. The distribution of underground rivers and caverns is investigated via hydrological exploration. The well location is selected, the wastewater pool is built, the blowout pool is used, and other environmental protection facilities, such as decontamination and diversion ditches, are used after the impermeability and bearing pressure have been tested. High-quality multilayer casing cement must be used to ensure that the drilling hole is completely separated from the environmental water and shallow rock mass. In the drilling operation, clean water drilling fluid is used at the top (1500 m) without any additives to avoid contamination of shallow groundwater, and harmless water-based drilling fluid is used in the range of 1500–2500 m of straight wells. Oil-based drilling fluid is used in inclined and horizontal sections below 2500 m. The fracturing gas test adopts the fracturing technology of pumping bridge plug to develop a fracturing fluid that does not contain heavy metals and toxic and harmful organic materials. The fracturing fluid will degrade automatically with the increase in temperature and time and is discharged back with formation pressure. The sewage treatment and water-saving and emission reduction measures should accurately control the total amount of wastewater. All drilling fluids are recycled and used in the closed circulation system. The reuse rate of industrial wastewater reaches 100%, thereby realizing zero discharge of industrial wastewater.

(3) Solid waste prevention and control. Water-based drilling fluid and cuttings are solidified in the wastewater pool, and the cuttings are collected and treated separately. Oil-based drilling cuttings are controlled not to fall onto the ground and treated harmlessly, and its draining into the wastewater tank is strictly prohibited. The collection, transshipment, and innocuous treatment are supervised in the entire implementation process. The oil-based drilling fluid is recycled using a drilling-fluid circulation system. Research and development of the advanced treatment of drilling cuttings and recycling technology and equipment should be conducted. The treated drilling cuttings are used for road and wellsite cushions, shale bricks, and concrete.

(4) Air pollution prevention and control. During gas production, the gas–liquid is separated from the gas-bearing regurgitated liquid by using the closed gathering and transporting process, and the separated gas is transported into the pipe network. In the gathering and transportation network, an empty combustion tower (cylinder) is set up at the field station. Once abnormal venting occurs, the fire can be ignited rapidly and automatically. Hence, methane gas emission can be avoided effectively. During gas test and back discharge, testing and production are conducted simultaneously while minimizing the discharge time. To reduce the emissions of greenhouse gases, solid particles, and sulfides, electric network drilling machines are used to replace diesel oil and electric pump fracturing units and diesel oil-driven drilling machines.

(5) Noise pollution prevention and control. The working time of earth-moving machines and gas fracturing before drilling are strictly controlled. The fixed mechanical equipment with muffler is selected, and the bases are installed to control noise effectively. The application of electric netting rigs is promoted to control noise effectively. The fracturing unit of electric pump is used instead of the diesel fracturing car to reduce the construction noise.

3.2.2 Innovation of green technology for solid mineral resources development

In recent years, "developing green mining industry and building green mine" has achieved remarkable results, and a large number of advanced examples have emerged to improve the protection of the ecological environment. Here, the following representative model enterprises are introduced as examples:

(1) Land conservation and utilization. The bauxite deposit of Guangxi Pingguo Aluminum Industry Company performs karst accumulation and laterite-type deposit with thin ore bed and large land occupation. Collecting more than 700 mu (1 mu = 1/15 of a hectare) of mine land every year and washing 2 tons of soil with water for every 1 ton of aluminum net ore are necessary. To solve the contradiction among mine soil, human, and land, a number of large plate filter presses were developed and collocated. Instead of the wet process, dry method was used to treat tailings. Pressure-filtered soil was used for reclamation and

the soil with better strength than that before reclamation was returned to local farmers.

(2) Mine sewage treatment. Dexing Copper Mine in Jiangxi Province is a world-class super large mine with more than 300000 tons of industrial wastewater discharged daily. As the mining area is located in the rainy part of Southern China, rainfall is heavy and concentrated during the rainy season. Rainwater flows through the waste rock forming into acid water, and the company adopts decontamination and diversion measures to discharge clean water directly into the river, so as to avoid pollution. The sewage goes into the acid reservoir for treatment. The wastewater treatment technology was innovated, and the heap leaching plant was set up in the waste rock yard for spraying. The new process of bacterial leaching–extraction–electrodeposition was applied. More than 1300 tons of electric copper was recovered from the waste rock every year. With the increasing capacity of acid water treatment, 500–800 tons of copper can be recovered from acid water annually via biological fluidization.

(3) Subsidence prevention of mined-out areas. Shandong Xinwen Mining Group has developed and adopted the technologies of comprehensive and general mining filling of raw gangue, self-flowing filling technology of ground gangue, pumping filling technology of coal gangue, and separation technology of coal gangue. Coal gangue is used to fill the goaf and replace the coal pillar, and the "three kinds of coal mines under the ground" is used to liberate the overburden resources and improve the mining recovery rate. Moreover, ground subsidence is reduced, and the environmental problems of stripping rock, tailings, and gangue are solved. The gas accumulation space in goaf is eliminated, the water inrush disaster of coal seam floor is prevented, and the harm in accidents of coal seam roof is reduced. The surrounding air and water pollution are effectively controlled, and the ecological environment is effectively protected.

(4) Utilization of tailings. Hebei Xuanhua Zhengpu Iron Industry Company used Xuanlongshi iron ore tailings to transform the wasteland at the bottom of Huangyang Mountain and changed a piece of unruly land in front of the mountains into a fragrant farmland for grapes, melons, watermelons, and other fruits and vegetables. The wasteland can also be used for planting rice. Harmless tailings can directly change wasteland into farmland, thereby increasing the area of cultivated land and improving the quality of farmland.

(5) Standardized construction of green mines. Guojiagou Lead–Zinc Mine of Jinhui Mining Co., Ltd. in Gansu Province has built a mining and mineral processing plant with an annual output of 1.5 million with proven resource reserves of more than 3 million tons. The factory with an ore-breaking workshop is located underground, and the mining system, which avoids pollution of noise and dust, is operated by driverless machinery. The water of mining and separating mineral and tailing water are recycled and wastewater discharge is absent. Around 70% of tailings is used to fill the goaf and improve the recovery rate. The mine ground is a very beautiful garden with a full green area according with the AAAA scenic spot standard. It has been listed as the nation's demonstration base for standardized construction of green mines (Zhang, 2018; Li et al., 2019b). This first-class mine in China has become a world leader in the new era (Figs. 1 and 2).

4 Suggestions

4.1 Improving the understanding of the dialectical relationship between protection and development

The Chinese government has stated that "Green mountains and clear water and mountains of gold and silver are by no means antagonistic, the key lies in the people, the key lies in thinking". This dialectical relationship between protection and development directs the manner of solving the problem of energy and mineral resource development.

Fig. 1 Overall view of the Guojiagou Lead-Zinc Mine of Jinhui Mining Industry in Gansu Province.

Fig. 2 Grinding Workshop of Guojiagou Lead-Zinc Mine of Jinhui Mining Industry in Gansu Province.

Conscientiously implementing the Central Committee's decision and arrangement on the delimitation and strict observation of the redline for ecological protection, objectively analyzing the status of the supply and demand of domestic and foreign resources, scientifically assessing the effect of the redline demarcation on the protection of energy and mineral resources, and prioritizing ecological protection is necessary. The policy of developing with protection and protecting for development should be coordinated with ecological security and resource safety to construct a system of green exploration and development that meets the requirements of high-quality development, and form a virtuous circle of protection and development.

4.2 Investigating and setting up policies and measures for the reasonable disposal of redlines involving mining rights

The redlines involving a large number of mining rights are decided by a specific stage of economic and social development in China, and the scope of exploration and development of mineral resources within the redline is scientifically defined and restricted. As a new control measure, the redline should fully respect the rights and interests of mining in accordance with previous laws, and the problems of mining rights involved in the redline should be addressed in stages and in a steady and orderly manner. We should focus on the study and formulation of policies, measures, and regulations to solve the problem of mining rights related to the redline. Mechanisms of spatial planning and dynamic adjustment must be established for the ecological protection of the redline. Moreover, the rules and access lists for the conversion of redline spaces must be arranged systematically. The legal system must be improved for the development of mineral resources and the protection of the ecological environment (Sheng, 2019).

4.3 Establishing environmental assessment system and technical standards for the development of energy and mineral resources

Considering the reality in China, learning from foreign experience, and following the requirements of the construction of ecological civilization, this study systematically summarizes the effects of the exploration and development of different regions and types of oil, gas, and solid minerals on the ecological environment. This study aims to construct an environmental evaluation system and technical standards for the development of energy and mineral resources in line with China's national conditions; to establish the classification and related standards for the ecological environmental effects of oil, gas, and solid mineral exploration and development; and to develop a timely and feasible assessment of eco-environmental effect.

4.4 Innovative development of energy and mineral resources and environment protection and treatment technology

To realize the close combination of the development of energy and mineral resources and ecological and environmental protection, we must adopt the mode of step-by-step development for the intensive utilization of resources, scientific exploration and mining, environmental protection, and the ecological development of closed pit mining area (oil and gas wells). Environmental protection and treatment technologies for the exploration and development of different mineral species should be innovated. The scientific and technological content must be enhanced. Effective technology must be further explored from the subjects of physics, chemistry, and biological action. Finally, the technical methods for environmental protection and treatment for energy and mining industries must be established.

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