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# Study on ecological restoration and landscape design strategies of abandoned mines

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### ABSTRACT

In recent years, with peoples environmental protection continuous enhance and the proposal of the national sustainable development strategy, the restoration and landscape reconstruction of abandoned mines have begun to receive the attention of the government, experts and scholars in various fields<sup>[1]</sup>. People realized that they can restore the abandoned land ecology through the knowledge of natural science and engineering disciplines. Landscape reconstruction and development can improve the living environment of residents which is also an important way to create economic value and realize the harmonious coexistence of human and nature. In this article, it is focus on the discussion which include how to carry on the ecological restoration of mining abandoned land, and the problem of landscape design modification, it is also put forward the concept of ecological recovery<sup>[2]</sup>, discuss on the relationship between ecological restoration and design modification, and how to implement both of them at the same time. The article introduces the methods of how to implement in details, to provide the reference for the future on rehabilitation and reconstruction of mine waste land in practice.

**Keyword:** Mine abandoned Land, Ecological Restoration, Landscape Design, Comprehensive Management and Environmental Protection

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Reform and opening up has promoted the rapid development of China's economy, the economic structure has also evolved. Among them, the development of heavy industry is particularly rapid, and the demand for mining is also increasing rapidly. Since the middle of the last century, mining has entered a golden age, which has brought continuous support to the development of heavy industry in China and greatly promoted the modernization of industry and the development of cities<sup>[3]</sup>. However, the reckless exploitation of resources has seriously damaged the balance of ecological environment, and the abandoned mines have

even hindered the local economic development. After mining, the land is left with accumulated solid wastes and many mining pits in straggly. Vegetation destruction is serious, biodiversity is sharply reduced, and natural disasters such as debris flow may occurred<sup>[4]</sup>, as shown in FIG. 1, an abandoned mine in a certain place. In addition, the uncontrolled exploitation and inadequate utilization of resources also lead to the gradual shortage and exhaustion of it. In many mineral-rich regions, there is a trend of resource depletion, leaving a large amount of land abandoned after mining. The restoration and reconstruction of these abandoned lands has become an urgent problem.



**FIG. 1 An Abandoned Mine In A Certain Place**

During the rapid economic development, people gradually realized that the importance of resources and environment and also the severe situation, sustainable development has become a new target, the focus of China's economic development will also transfer from polluting heavy industry to environmental friendly resource-efficient industries, advocating "low carbon" of a new mode of sustainable development become the trend of The Times. In the future, The recovery and reconstruction for abandoned lands of mines will become the hot issue by social attention, especially in how to restore vegetation and

biodiversity of mine, how to design the landscape of abandoned mine-lands, and transform it into a usable place integrated with the city's human and natural environment, will get the attention of experts and scholars in various fields.

## **1. Restoration and management of abandoned mines**

### **1.1 The management and restoration in foreign**

Since the end of the 19th century, some countries began to focus on the ecological and environmental issue of the mining areas, some

prominent countries like the United States, Australia and the United Kingdom<sup>[5]</sup>. The mine environmental governance research of them is focus on ecological restoration, issued in the United States, the act of Open-pit Mine Management And Ecological Restoration Of Mining Abandoned Land, it is clarified the attribution of responsibility for environmental problems of abandoned mine lands, for now, for the cultivation of abandoned lands of mines in the United States have accounted for 80%<sup>[6]</sup>, has achieved good results.

In addition to promulgation of relevant laws and regulations, Australia has also established special institutions to manage the ecological restoration of land in mines, and promoted cooperative research in different fields of natural science and social science, thus achieving scientific and effective management of abandoned land in mines. And also, Japan, Germany, the United Kingdom and other developed countries have involved in mine land environmental protection work for a long time, the relevant technology is also in the forefront of the world. Such as Japanese akashi channel was a very productive quarry, while excessive sand mining make the mountain of the mine being destroyed, since the end of last century, the Japanese government began to restore and design the local ecological environment and landscape, through the construction of cultivated plants irrigation system and water circulation system, construction of infrastructure, etc., to transform it into the channel park, returned to the local ecology, made it to the habitat of birds and animals, created economic benefits at the same time.

## **1.2 The management and restoration in domestic**

Due to the influence and restriction of

economic development level and scientific and technological level, China's research on mine land resources started relatively late, but in recent years, due to economic development, scientific and technological progress and the strong support of government policies, the related management and restoration of mine develop rapidly and progress obviously. At the end of the last century, China promulgated the "land reclamation regulations"<sup>[7]</sup>, which opened the curtain of land environmental management in mining areas. The initial management was relatively simple, mainly focusing on the restoration of vegetation, and simple environmental management was carried out on abandoned land in mines. With the gradual maturity of the theory and the reference of foreign experience, the landscape reconstruction of abandoned mines has gradually been paid attention to, and landscape design has begun to be applied in the restoration and reconstruction of abandoned mines. After entering this century, people started to use chemistry, ecology, economics and various disciplines of knowledge to make it comprehensive governance, began to use abandoned lands of mines to create new economic value, using the knowledge of the ecology to transform abandoned lands of mines, and has achieved the organic unity of economic value and ecological value. At the present, there are lots of abandoned lands of mines has been transformation<sup>[8]</sup>, transition to the mine park, garden, botanical garden, etc. For example, daze mountain mining area in pingdu city of Qingdao has left a pit with a total area of 40% due to stone mining, and the local vegetation, landform and water system have been seriously damaged. After the restoration of vegetation and terrain, the remodeling of landscape, it has regained its vitality and

become a scenic spot with beautiful environment and ecological harmony. While, there are many problems in the management of abandoned mines at the same time. For example :(1) there is a lack of effective supervision and guarantee mechanism, the implementation of relevant policies and regulations is not in place, and some mines are not able to achieve ecological restoration and landscape reconstruction due to the form of attribution is more complex and the lack of funds for post-process environmental management. (2) due to China's abundant resources and vast territory, as well as the variety and quantity of mines, it is difficult to recover. (3) due to the weak awareness of

environmental protection and backward concept and technology, the efficient environmental protection management mode of mining and treatment has not been achieved at present, and it is still in the stage of passive treatment. (4) policies and regulations still need to be improved, and environmental protection publicity is not enough. Although the country has issued relevant laws, but there is still a lack of specific implementation of management methods and provisions, so that the effectiveness of legal constraints weakened. At the same time, due to insufficient publicity of education, people and local governments' awareness of environmental protection is not strong enough.



**FIG. 2 Abandoned mines were transformed into flower industrial park**



**FIG. 3 An orchard transformed from an abandoned mine**

## **2. The concept of ecological restoration of abandoned mines**

Derelict mine land refers to land that cannot be used continuously after mining due to the damage caused by mining activities<sup>[9]</sup>. These

lands cannot be directly used for planting and construction due to soil damage or pollution and damage to the surface structure. Abandoned mines are divided into open and non-open ones. The vegetation in the open mines is seriously damaged and difficult to be repaired. The vegetation in the non-open mines is small but easy to cause surface subsidence, thus causing serious impacts<sup>[10]</sup>. According to the industrial process of mining industry, abandoned mine lands can be divided into four types of regions<sup>[11]</sup>, including tailings areas formed by tailings of coal mining stones left after coal screening, dump sites formed by waste ore and soil accumulation, subsidence areas left after mining, equipment and transport vehicles required for mining business, and land occupied by buildings. The American ecological society defines ecological restoration as restoring the ecosystem damaged by human beings to the local ecosystem with biodiversity and dynamic balance<sup>[12]</sup>. The essence of ecological restoration is to restore or rebuild the environment damaged by human beings into an ecosystem in harmony with the local nature. The core of ecological restoration and reconstruction of abandoned mining land lies in restoring the structure and function of the ecosystem so as to improve the productivity and stability of the ecosystem<sup>[13]</sup>. Therefore, ecological restoration and reconstruction through engineering technology, biotechnology and other measures to restore it to a reusable state is the basis of sustainable landscape design of abandoned mining land.

### **3. The environmental impact of abandoned mines**

#### **3.1 Landscape fragmentation**

The degradation of landscape can be divided into structural degradation and functional

degradation. Structural degradation refers to the phenomenon that the functional links between various ecosystems in the landscape are broken or the degree of connectivity is reduced. Functional degradation refers to the deterioration of stability and service function caused by the change of landscape heterogeneity<sup>[14]</sup>. Mining activities including open-pit mining and underground mining both of them will cause changes in the surface landscape. In open pit mining, topsoil is stripped off, land is excavated, ground is damaged, and tailings, fly ash and smelting slag are piled up.

#### **3.2 Pollution and diffusion**

Mining activities will bring serious pollution to the environment of surrounding areas. The pollution sources mainly include minerals and wastes piled up in the open air, mine waste water produced by mining and toxic mineral elements. Minerals and wastes piled up in the open air are prone to oxidation and spontaneous combustion, and a large amount of harmful gases such as CO<sub>2</sub>, SO<sub>2</sub>, NO<sub>2</sub> and mineral dust will threaten human health, affect air quality and pollute the surrounding environment. At the same time, the mine waste water discharged in the mining process contains a large number of suspended substances and pollutants, most of which will be directly discharged into the environment, resulting in a decline in the quality of groundwater and soil. At the same time, toxic mineral elements will exist in the tailings, which will aggravate soil pollution and degradation with the waste piling up and have adverse effects on the growth of plants.

#### **3.3 The process of destroying water**

Mining damages vegetation causes the decrease of water conservation, and damages

the infiltration process of surface runoff. At the same time, underground mining will change the direction of underground water flow, which will seriously interrupt the flow of rivers and streams. At the same time, the river, as the water transport channel, is often used as the direct way of wastewater discharge in mining areas, and the riverbed is often used as a storage yard to obstruct flood discharge. However, riparian vegetation zones, such as riparian shelter forests, native aquatic and hygrophytic plant communities, which play a role in water as conservation and habitat provision. But they are often destroyed in curing treatment, which directly affects the ecological effects of rivers.

#### **4. Ecological restoration and landscape design strategies of abandoned mines**

##### **4.1 Surface trace treatment**

To remove the fragmentation of the rock structure left by mining, and remove this huge and unsafety pumice stone, we can use mechanical and manual tools. Practical investigation should be carried out on the ground performance on the mine, and the concealment performance with cracks or unstable basement and potential safety hazards should be handled or cleared<sup>[15]</sup>. For places that are too steep, slope cutting should be carried out to slow down the slope, reduce the possibility of rock falling or landslides, and facilitate subsequent landscape design. In surface treatment, suitable rock slope can be used to build steps. In addition, drainage and water supply facilities can be built in the bottom cleaning stage.

##### **4.2 Disposal of abandoned mining facilities**

Based on the surface characteristics of abandoned mines, the remaining landmarks, underground buildings and facilities are

preserved, dismantled and transformed according to the coordination degree of the remaining buildings and facilities with the environment and the difficulty of transformation. Demolition of construction facilities that will cause secondary pollution, leave potential safety hazards and are out of harmony with the environment, repair and retain infrastructure that can be used, and construction facilities that can be repaired and transformed, especially those with distinctive characteristics or ornamental features, may be retained and repaired as features.

##### **4.3 Pollution control**

The treatment of mining pollution is an important part of ecological restoration. For solid waste, there are three common treatment methods: heap treatment, reclamation treatment and landfill treatment<sup>[16]</sup>. Stacking treatment is to select the appropriate site of the other party on the premise of not polluting the water body, not releasing harmful gases and causing natural disasters, comprehensively consider various factors, carefully pile solid waste, cover soil, sand and stone on its surface, and conduct greening treatment or chemical surface treatment. Landfill treatment is a method to deal with solid waste in order to avoid huge losses caused by goaf collapse. Cement and other adhesives can be added into tailings to fill the underground goaf. When dealing with polluted wastes, the water body should be inspected to avoid water pollution. Reclamation treatment is an ideal method of solid waste treatment, which requires soil storage during mineral mining, and then backfilling and vegetation planting after mining, so that agricultural cultivation can be carried out with little harm to the environment and good recovery effect. For polluted water bodies, sewage is transported to sewage treatment

plants and treated by activated sludge technology.

#### **4.4 Vegetation restoration**

Topsoil and vegetation in mining areas are often damaged beyond recognition, and the overall ecosystem is damaged. In the short term, the main objective of vegetation restoration in mining areas is to control soil erosion, reduce disasters, and play an important role in protecting soil from erosion, promoting the formation of fine particles and the accumulation of nutrients. Ecosystem restoration can be achieved through natural processes, which is through ecological succession. This natural recovery process works when the damage is not severe, and sometimes takes much longer than one might expect. If human disturbance is stopped and forests are closed, long-term and slow upward succession of vegetation will occur, while downward succession is usually rapid. It is very important to use native plants to restore vegetation communities. Through observation, reasonable selection of plant species, especially those plants that are naturally settled on abandoned land of mining industry can adapt to extreme conditions, have strong tolerance and plasticity, and form multi-level plant communities with cultivated plants, so as to form multi-structure ecosystems.

#### **4.5 Landscape remaking**

According to the geomorphic original form, the use of the particularity of the surface morphology, coordinate flat plane with slope surface consistency, combining with the spatial planning, close to the reshaping of the natural terrain design, reasonable use of unique surface morphology retain its unique characteristics of abandoned lands of mines, near the city planning of abandoned lands of

mines, and its geographical location, explore its tourism resources available resources or farming animal husbandry, its design exhibition, built in the park, playground, plantations and wildlife habitats, etc., and gives the new value, make mining abandoned land natural resources and human resources into economic and social benefits, Achieve sustainable development.

#### **5. Principles of ecological restoration and landscape design of abandoned mines**

The transformation of abandoned mines can be divided into three aspects, namely, pollution control, ecological restoration and landscape design<sup>[17]</sup>. The three principles to be followed in carrying out these three tasks are nature first, emphasis on protection, and promote restoration. The priority of nature is to respect the original natural ecological environment of abandoned land, restore the community of plants and animals, and repair the surface morphology. Protection is to protect the existing natural environment, according to the multi-disciplinary comprehensive knowledge of scientific design and transformation; Restoration is the use of technology to restore the natural environment. In the specific implementation, the principle of 3r, namely reuse, recycling and streamlining, should also be followed<sup>[18]</sup>. Reuse is to make full use of abandoned building facilities and natural environment in abandoned land, so as to better integrate them into new uses, achieve harmony and unity, do not destroy, do not waste, and endow them with new value and significance<sup>[19]</sup>. Recycling is to rationally arrange all kinds of natural resources in abandoned land to restore balance, isolate the pollution system, and establish a natural recycling recovery system, so that pollution can be improved. The principle of streamlining refers to not building more

man-made construction facilities, protecting the fragile natural ecology, utilizing the original resources for development, and minimizing the cost and secondary damage to the environment<sup>[20]</sup>.

## 6. The epilogue

The abandoned mines in China are widely distributed and have a large total area, so there is an urgent need for their ecological restoration and landscape remodeling. The transformation of abandoned mines requires the comprehensive utilization of knowledge in the fields of natural ecology, landscape design, economics and so on, which is a systematic project requiring comprehensive consideration. Various types of mining land, should take measures according to the practical problem, ecology and related engineering disciplines collaboration can be processed, the landscape of land degradation and through landscape design, can achieve the purpose of the reused and "waste", and the balance of ecological degradation of land resources shortage, environment worsening. It is believed that under the premise of improving people's awareness of environmental protection, adhering to the sustainable development strategy, improving the utilization rate of land resources through the transformation of abandoned mines, and paying attention to the ecological value, economic value and cultural value of abandoned mines, will make the ecological restoration and landscape reconstruction of abandoned lands further develop.

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