Preserving collieries: a form of urban regeneration for mining cities in China

Yiling Hu

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Abstract
Most mining cities in China were formed in the 1950s. Due to resource depletion and the single industrial structure, China's mining cities have been declining since the 1980s, and industrial transformation and urban renewal have become the priority for the development of mining cities. Meanwhile, there exists a vast amount of mining heritage that has not been fully preserved and utilized. This heritage has a unique value for use. Through sufficient preservation and adaptive use, it can enhance the vitality of cities and promote the development of related industries, which is a good opportunity to facilitate urban regeneration and industrial restructuring. Thus, this thesis proposes to study the adaptive reuse of collieries as industrial heritage and to evaluate their potential as a viable form of urban regeneration for mining cities in China. The research includes an overview of coal mining heritage and existing preservation strategies, a study of mining cities in China, and a proposed design guideline of the selected city Jiaozuo as an example. The goal of the thesis to provide strategic guidelines for the future adaptive reuse of collieries to facilitate healthy urban regeneration.

Keywords
coop mining heritage, institutional heritage, urban transformation, heritage tourism, heritage corridor

Disciplines
Historic Preservation and Conservation
PRESERVING COLLIERIES: A FORM OF URBAN REGENERATION FOR MINING CITIES IN CHINA

Yiling Hu

A THESIS

in

Historic Preservation

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements of the Degree of

MASTER OF SCIENCE IN HISTORIC PRESERVATION

2021

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Acknowledgements

I would like to express my sincere gratitude to my advisor, Fon Wang, for her great support during my thesis writing. Covid-19 prevented us from communicating face to face. Being in a different country, time differences, and often poor internet access made it more and more difficult for us to communicate. I thank her for her patience and encouragement, for thinking that my thesis topic was exciting and valuable, and for always being there to help and guide me. When I encountered research difficulties, she helped me find solutions to my problems and provide resources that could help me. She has helped me tremendously in both the main structure of my essay content and in the analysis of specific problems. She also carefully helped me correct language irregularities and helped me express my research better. In addition, I would like to thank the professors who provided me with comments and suggestions and helped me to enrich my ideas for the paper during the two presentations.

Finally, I would like to thank all the professors, staff, and students at HSPV for their help and guidance during my study of historic preservation. We are all about to embark on a new journey, and I hope all is well.
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1 Introduction

Most of China's mining cities were shaped in 1950s, and due to resource depletion and single industrial structure, China's mining cities as a whole have been declining since 1980s, and industrial transformation and urban regeneration have become the focus of mining city development. At the same time, mining cities, taking coal mining cities as an example, there exists a large number of coal mining heritages that have not been fully preserved and utilized. This heritage is rich in material and cultural legacy. The full preservation and reuse of them is also a good opportunity to promote urban regeneration and industrial restructuring, which can help mining cities entering a period of decline to find a new development path.

Thus, this thesis proposes to study the adaptive reuse of collieries as industrial heritage and to evaluate their potential as a viable form of urban regeneration for mining cities in China. The research includes an overview of coal mining heritages and existing preservation strategies, a study of mining cities in China and a proposed design guideline of the selected city Jiaozuo as an example. The goal of the thesis to provide strategic guidelines for the future adaptive reuse of collieries to facilitate healthy urban regeneration.

1.1 Background

In the 1960s, industrial cities in Western countries were affected by the continuous decline of resource reserves, and urban development began to regress, seeking a path of transformation. Many of China's industrial cities were formed in the early stages of China's industrialization and made significant contributions to the country's
modernization and development. After the 1980s, the country's industrial structure developed in a more balanced, environmentally friendly and technology-led direction. As the economic level improved, some industrial cities with a single industrial structure or outdated technology gradually lost their development advantages, and some other mining cities also faced the problem of resource depletion, leading to a slowdown in development, a decline in economic level and prominent urban problems. In this setting of decline, mining cities began to transform. Over the past decades, although some cities in China and also other countries have made certain achievements in transformation and development, problems such as environmental degradation and high unemployment rate are still prevalent, and the growth rate of urban economy is hardly comparable to the fast development period before the decline. Hence, the transformation of industrial cities is still a worldwide problem.

China's mining cities as a whole have been in decline since the 1980s, and the transformation and development of the cities have become the focus of attention of the whole society. In order to solve the series of problems that emerged during the development of mining cities and reverse the trend of urban decline, and to guide their healthy and orderly development, our government has made long-term efforts and exploration. Most of the transformation of China's mining cities started in the mid-late 1990s, and only 20 years have passed since then, with a few cities such as Zaozhuang, Fuxin and Jiaozuo achieving results, but the overall decline of resource-based cities has not been effectively controlled. In 2013, the National Sustainable Development Plan for Resource-based Cities (2013-2020) made clear plans for 262 resource-based cities in terms of development direction, resource utilization, industrial development and
environmental protection. The document identifies 69 cities in the resource depletion stage, and Jiaozuo is among the list. As a typical mining city in decline, studying the role of preserving coal mining heritage on Jiaozuo's urban regeneration can help provide development ideas for other cities, which is why Jiaozuo was selected as a subject in this study.

Many of China's coal mining industrial heritage not only witnessed the country's industrial development, but also visually interpreted the civilization of the industrial era. This kind of coal mining industrial heritage, though it has an important role in industrial civilization, after the city enters the stage of rapid development, the adverse impact on the overall structure layout and ecological environment of the city gradually comes to the foreground. Many cities will idle the industrial resources of coal mining industrial heritage, thus causing many buildings, structures and equipment, etc. to be demolished and abandoned, and many of their values are not fully recognized and reflected. In the protection of coal mining industrial heritage, there are also many ineffective situations where heritage is completely eliminated and the land was soon redeveloped, resulting in a gap in the historical process of urban development, and more seriously, the collective memory of several generations of workers, which have been gradually erased due to the excessive development and construction of the city. Over the years, China has gradually begun to pay attention to the industrial heritage of coal mines, and through the study of successful foreign cases and theories, it has gradually increased the efforts to protect the industrial heritage of coal mines, and has achieved good results and social benefits.

In summary, the conservation and reuse of coal mining industrial heritage has a non-negligible contribution to future urban development. It needs to be analyzed and
studied to find solutions to make the coal mine industrial heritage have vitality again, which has an important reference value for the display of various aspects of culture, society and history in the course of urban development. The full preservation and reuse of coal mining heritage is also a good opportunity to promote urban regeneration and industrial restructuring, helping mining cities that have depleted resources and entered a period of decline to find their own development path.

1.2 Scope of Study

This study focuses on the adaptive reuse of collieries as industrial heritage and evaluates their potential as a viable form of urban regeneration for mining cities in China. Despite some successful examples of the adaptive reuse of industrial heritage in China’s mining cities, collieries are an industrial type that has not been successfully integrated into adaptive reuse or urban regeneration schemes while many declining coal mining cities are still searching for development strategies. Such indifference has led to unexplored possibilities of these available resources and has led to a greater loss in future development of mining cities. Collieries, owing to their requirements as a heavy extractive industry and their unconventional material scale, are difficult industrial sites to reuse. Recommendations for potential modes of adaptive reuse of collieries for the selected city Jiaozuo based on evaluation and analysis of their values and applications can assist in raising the awareness of the significance of coal mining heritages as well as provide strategies for future reuse and contribution to urban regeneration in China’s mining cities.
The research first conducts an overview of coal mining and mining heritages and to identify their specific characteristics as a form of extractive industrial heritage. For coal mining heritage, different excavation methods and changing mining techniques can have a significant impact on the final form of coal mining heritage, as well as on the subsequent preservation and adaptive reuse methods. Therefore, this section begins with a study of coal mining methods and mining techniques. This is followed by a study of what constitutes mining heritage and its characteristics, which provides the basis for a later study of preservation strategies.

The research is followed by study of preservation strategies of collieries. Preservation methods of collieries and associated industries vary according to their characteristics and broader context. While analyzing two basic areas of preservation which include ecology as well as areas concerning architecture, city planning, landscape and historic preservation, a summary of different preservation methods is created based on the criteria applied to major sites that include individual structures, larger colliery complexes, and colliery landscapes.

This paper then continues to focus on urban regeneration in China’s mining cities. China's mining cities are very similar in that their rise and development is closely related to the development of minerals and mining. Likewise, the depletion of mineral resources has brought urban development to a difficult situation. The current situation of mining cities in China, the relationship between mineral resources and urban spatial forms, and the basic forms of urban regeneration are studied to provide directions for the preservation of coal mining heritages to promote urban regeneration.
Finally, this paper studies Jiaozuo, a typical mining city in the resource depletion stage, as a selected subject. This section examines the history of urban formation and spatial patterns of the city and the existing coal mining heritages, and then analyzes the values of those heritages. Some typical cases of preservation of coal mining heritages are also studied. Based on these, preservation principles and strategies of Jiaozuo are proposed.

1.3 Methodology

The methodology of this study includes mainly theoretical research, case studies, study of data drawn from archival investigation and field research.

The theoretical study is divided into two parts: colliery study and mining city. Colliery study mainly includes the interpretation of relevant concepts, definition and classification, and studies representative heritage reuse strategies, providing a theoretical basis for later research. The section of mining city mainly includes the meaning of mining city, the basic theory, the current situation of coal city development in China, etc., which provides the theoretical basis for the study of urban renewal and transformation strategy.

A case study of Jiaozuo was conducted in the study of coal mining heritage preservation and Chinese mining cities’ urban regeneration. Case studies of several existing coal mining heritage reuse projects are also examined in the context of reuse strategies.

Field research was conducted in the study of Jiaozuo city. The current status of Jiaozuo city was documented, while the current accessible coal mining heritage was
investigated and the environment around Zhucun Mine, the focus of this paper, was recorded.

At the same time, research on the urban development and industrial development of Jiaozuo was conducted in the local library of Jiaozuo through local coal mine records and historical maps. By sorting out and analyzing the historical development and spatial form changes of Jiaozuo city, we analyzed and summarized the relationship and characteristics of urban space and industrial production, and laid a theoretical foundation for the development of Jiaozuo coal mining city.

1.4 Literature review

1.4.1 Studies outside China

The earliest overseas research on the conservation of coal mining industrial heritage was conducted in the United Kingdom, initially in the 19th century, and then in the 1960s, when a comprehensive theoretical system of industrial heritage conservation was formed within a decade. In addition, although scholars from other countries are late to focus on the study of coal mining industrial heritage, they have developed rapidly in recent years, specifically in the past 30 years, and a large number of scholars have emerged with rich research, whose theories not only focus on the conservation and utilization of industrial heritage, but also on the study of coal mining industrial heritage, filling the gaps in the study of coal mining industrial heritage in various countries.

Through the analysis of different cases, many scholars have proposed the practicability of combining the reuse of coal mining heritage with local tourism, which provides a rich theoretical basis for this paper. The urban regeneration discussed in this
paper relies heavily on the promotion of tourism by coal mining heritages. In 1991, P. Yale introduced the classification of industrial heritage tourism resources, and introduced the case of Ironbridge Gorge, the first World Heritage industrial site in the UK.\textsuperscript{1} The difference between industrial heritage tourism and heritage tourism began to emerge during this period, and research on industrial heritage tourism began to break away from the framework of heritage tourism and form its own development theory. J. Arwel Edwards developed a framework for classifying industrial heritages based on an analysis of the potential value of the core attractions of industrial heritage tourism such as mines, open pits and other industrial facilities, and explored the development of industrial heritage tourism using Wales and Spain as examples.\textsuperscript{2} Industrial heritage tourism has been used as a process of economic regeneration in industrial cities,\textsuperscript{3} while Llurdes suggests that the reuse of industrial heritage should include the transformation or expansion of the function of mining areas.\textsuperscript{4} For example, from a completely industrial area to a tourist destination, leading to the development of local service industries, thus contributing to social and economic transformation. Calvin Jones and Max Munday explored the impact of industrial heritage conservation and regeneration on urban economic development, using Blaenavon Industrial Landscape Park in South Wales as an example, and concluded that industrial heritage tourism is beneficial for local economic

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development. Grete Swensen and Rikke Stenbro selected three typical Norwegian industrial cities - Oslo, Drammen, and Larvik - to study the role of industrial heritage in the transformation of urban industrial areas from an urban planning perspective. Generally speaking, the research on industrial heritage of coal mines abroad has gradually increased, and the models and strategies for their conservation and reuse have been enriched, but there are relatively few concrete practices on the conservation and reuse of industrial heritage of coal mines. Among the 43 industrial heritage sites announced by UNESCO, only two industrial heritage sites related to coal resources, the Customs Union coal mines in Germany and the British coal mining town of Blaenavon, are currently being evaluated. Germany's Ruhr industrial zone, as a gathering area of industrial buildings throughout Europe, has many parks that have been reused to become an important landscape "green lung" in the region. Birmingham mine in the United Kingdom, based on the situation of the coal mine, combines the development of tourism industry and the preservation of coal mining heritage. The French Lorraine mining area, based on the needs, focuses on land remediation to set up a separate department to take charge of matters, improve the organizational structure, and promote the development of the way of transformation and reuse of mining areas. Most of these parks are designed to retain the industrial production facilities in the original site to the greatest extent, transforming them into open spaces for public recreation and entertainment, creating

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many highly distinctive landscapes. At the same time, these renovation and design projects have, to a certain extent, solved a series of social problems such as employment, economic development and human living environment caused by the decay of the coal mining industry, which not only has a significant practical act, but also creates a model for the reuse of other coal mining heritage.

1.4.2 Studies in China

Coal mining industrial heritage is one of the important types of industrial heritage in China, and compared to foreign countries, related conservation and reuse studies started late, and only gaining initial attention in the 1990s. China's research on the conservation of sites within mining sites first appeared in the "Notice on the Establishment of Geological Protection Areas" promulgated in 1987, and in practice, most of the research was conducted around mining subsidence areas to improve and restore their ecological environment. In 2004, the Ministry of Land and Resources issued the Notice on the Declaration of National Mine Parks, and one year later, the first batch of national mine parks was approved, which means that China started to protect and reuse mine resources. 72 mine parks were identified in 2010 and 2013. In 2010 and 2013, a total of 72 mine parks were qualified for construction. Research on coal mining industrial heritage has gradually increased, but in general, most of the research on coal mining industrial heritage also stops at transforming it into a mine park for touring and displaying.

More and more scholars in China have started to conduct research on the reuse of coal mining heritages. Liu Fuying mainly put forward the viewpoint of collaborative
regeneration and studied the regeneration methods for sites and production facilities of industrial abandoned sites, emphasizing the system coordination in the process of use.\(^8\) Liu Boying and Feng Zhongping mainly gave a comprehensive description of the definition, research methods, value identification and conservation methods of industrial heritage.\(^9\) Wang mainly conducted an in-depth study on the conservation and renewal of industrial buildings, and proposed various theories and design approaches of renovation through famous cases at home and abroad.\(^10\)

Taking Haizhou Mine Park as an example, Wang Ying and Liu Xuemei focused on several relationships and the composition of investment subjects that must be dealt with in the development of industrial heritage tourism in resource-depleted cities.\(^11\) Xie Mingyang summarizes the interrelationship between urban renewal and coal mine industrial heritage, discusses the reuse approaches, and the impact on urban development under different models using Pingdingshan as an example.\(^12\) Deng Yuanyuan and Cao Xiaojin specifically analyze the current situation of China's coal mining heritages, which contain the spatial distribution characteristics of China's coal industrial industry and the strategic concept of industrial tourism development of coal mining heritages.\(^13\)


\(^12\) 谢明阳. 城市更新视角下的煤矿废弃地工业遗产保护与再利用研究(Study on Industrial Heritage Protection and Reuse in Coal Mine Waste Land from the Perspective of Urban Renewal—A Case Study of Pingdingshan City). MS thesis. 合肥工业大学. 2019.

Through reviewing the above literature, this paper takes the urban regeneration of declining coal mining cities as the starting point and combines the research on industrial heritage tourism with the characteristics of coal mining heritage itself. This paper combines the analysis and research on the reuse of coal mining heritage from the perspective of tourism with the research on the strategy and development model of coal mining heritage reuse, and further summarizes the reuse methods and provide guidelines in the urban perspective.

2 An Overview of Coal Mining and Mining Heritage

2.1 Coal Mining Methods

In the case of coal mining heritage, the facilities and equipment required, the scale of mining, the form of the mine, and the degree of damage to the original landscape vary greatly from one excavation method to another, and thus have a significant impact on the final form of the coal mining heritage. Preservation strategies will be affected accordingly.

The various methods of coal mining can be divided into two main categories: surface mining and underground mining. Surface and underground coal mining is a broad range of activities with many variations in equipment and methods. The choice of coal mining method depends on many technical, economic, and social factors. Technical factors include, at a minimum, the number of coal seams, the thickness and steepness of

each seam, the nature and thickness of the overlying rock strata, the quality of the seam, 
the surface topography, surface features, and the available transportation network. 
Economic factors include energy demand and its growth, the availability and cost of 
alternative energy sources, coal quality and coal preparation costs, coal sales prices, 
technological advances that affect production costs, and environmental legislation. Social 
factors include the previous mining history of the area, ownership patterns, labor 
availability, and local or regional government support.¹⁴

¹⁴ "Coal Mining | Definition, History, Types, & Facts". *Encyclopedia Britannica*, 2021, 
2.1.1 Surface Mining

Surface mining is a method of mining in which topsoil and rock are removed directly from the ground to reveal the coal seam. Surface mining requires shallow and thick coal seams, and in the process of mining, the field is usually divided into several horizontal strata, and the coal is mined from top to bottom, forming a stepped pattern in space (Figure 1). Surface mining uses more large equipment than underground mining and occupies a large surface area, with large surface mines covering 10 to 100 km². Surface mining is the preferred method of coal mining in the world's largest coal-producing countries because of its low cost, high recovery rate, high efficiency, and safety. Because there are no safety hazards such as permeability, gas, roofing,

Figure 1 Huangshi National Mine Park, the open pit of Daye iron ore mine known as “the first mining pit in Asia”. Source from baidu.com.
spontaneous combustion, etc., the mortality rate of miners' million-ton coal mines is low, and the degree of mechanization is high, therefore, surface mining has outstanding advantages in terms of safety production.\(^\text{16}\)

2.1.2 Underground Mining

![Underground Mining Image](shandong-energy-zimine-group-bayan-gaole-coal-mine-source-from-mkzdh.com)

Underground mining refers to the way of excavating a series of shafts from the surface to the underground coal seam and entering the coal body to extract the coal resources buried too deep (Figure 2). The purpose of digging a shaft is to provide all necessary conditions for coal mining, including the form, size, number, and layout of the shaft to suit different coal mining processes. The coal mining system is also an important

\(^\text{16}\) 李柱. "析我国露天煤矿开采技术现状及发展趋势(Analysis of the current situation and development trend of surface coal mining technology in China)." 中国科技财富 15(2012).
part of shaft mining, including ventilation system, drainage system, power supply system, communication system, monitoring system, and emergency evacuation system.\(^\text{17}\)

According to the technology to break down coal, there are three types of underground coal mining: mechanical coal mining, blasting coal mining, and hydraulic coal mining. Mechanical mining is mainly divided into two types: room and pillar mining and longwall mining, the latter being the predominant method. The long-wall mining method has a long working face, generally, 100-200 m, which can accommodate coal mining machinery with high power and high production capacity, and thus has large output and high efficiency.\(^\text{18}\)

### 2.2 Chinese Coal Mining Technology

Coal mining in China began more than a thousand years ago, and mining methods have changed dramatically with technological advances. Changes in mining technology have profoundly influenced the pattern of mines. The constant updating and improvement of mining machinery and equipment have influenced the characteristics of coal mines in different eras, marking the continuous inheritance of coal mining culture.

#### 2.2.1 Manual Mining: the main method of ancient coal mining

In ancient times, all coal production was done by hand: coal mining was done by hand with iron picks and other tools, transportation was done by humans strength and included basket pulling, lifting with windlass, and drainage was done by picks or bailing

\(^{17}\) 张登明, 煤矿开采方法(Coal mining methods). 中国矿业大学出版社, 2009.

\(^{18}\) 廖健, 郭保平, and 杨科. 采煤矿论(Introduction to Coal Mining). 中国矿业大学出版社, 2011.
bucket to draw water. Due to the limitations of production tools, lifting, and drainage capacity, and equipment conditions, people could only mine the shallow coal seam, and the shaft of the coal kiln could not be too deep. According to the geological and geographical conditions of coal resources, coal kilns are mainly in the form of straight shafts, inclined shafts, and flat mines, which include roadway type coal mining method, jumping type coal mining method, slotting method, and stump type coal mining method, etc.  

2.2.2 Blasting Coal Mining: the main modern coal mining method

Starting from the 1820s, coal mining in China moved from manual mining to machine mining. This was marked on the one hand by the adoption of steam-powered machinery for hoisting, dewatering, and ventilation, which created conditions for extracting coal seams deeper from the surface, while mining was still primarily manual at first. On the other hand, there were fixed funds and organizations. Capitalist business methods were adopted, which had the basic characteristics of modern industry.

2.2.3 Mechanical Mining: the main contemporary coal mining method

In terms of the history of coal mining technology development in the world, mechanized coal mining started in the 1940s. At that time, Britain and the former Soviet

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Union produced coal mining machines one after another. In the early 1950s, Britain and the former Federal Republic of Germany produced roller coal mining machines, bendable scraper conveyors, and monoblock hydraulic pillars, which greatly advanced the development of coal mining mechanization technology. From the 1960s to the beginning of the 21st century, coal mining machines have gone through four generations, namely fixed drum coal mining machines, single rocker drum coal mining machines, double rocker drum coal mining machines, and electric traction coal mining machines. In China, from the early 1950s to the early 1970s, coal mining was mainly transitioned from semi-mechanization to general mechanization. The outdated coal mining technology was gradually eliminated and the long-wall coal mining method was introduced, which improved the level of coal mining mechanization and led to a major change in China's coal mining technology.21

2.2.4 China's Current Coal Mining Technology and Development

From the perspective of mining methods, China's coal is mainly underground mining. In the world's major coal-producing countries, such as Canada, the proportion of surface mining production is 88%, Germany is 78%, the United States is 61.5%, Russia is 56%, while the proportion of China's surface coal mining is small. According to the statistics in 2008, China's underground mining accounted for more than 95% of the total coal production. Like other major coal mining countries in the world, China also takes surface mining as a priority way to increase coal production and tries to realize surface production.
mining as long as conditions allow, in order to reduce the cost of mining, improve labor efficiency, increase the recovery rate of resources, shorten the construction period, and reduce the million-ton mortality rate.\textsuperscript{22}

There are two main reasons for the low proportion of surface mining in China: first, there are few coal fields suitable for surface mining, and the coal seams are buried deeper, according to the statistics of China Coal Development Strategy Research Group, the coal reserves suitable for surface mining in China only account for 4.1% of the national coal reserves, totaling 41.243 billion tons, concentrated in Shanxi, Inner Mongolia, Shaanxi, Xinjiang, etc.\textsuperscript{23} Second, the coal fields suitable for surface mining in China are mainly concentrated in economically underdeveloped and environmentally fragile areas, where coal demand, transportation conditions, and reclamation capacity are relatively weak. Surface mining requires a high initial investment that local governments cannot afford.

2.3 Mining Heritage

Mining heritage encompasses much more than the physical structures of mines and related industries that have survived to this day. Therefore, when preserving and reusing mining heritage, we cannot limit ourselves to these aspects.

\textsuperscript{22} 高书红. 煤矿废弃地景观再生规划与设计策略研究(Study on Planning and Design Strategies of Abandoned Coal Mine Land Landscape Regeneration). Diss. 北京林业大学.
\textsuperscript{23} Ibid.
2.3.1 Basic Definition of Mining Heritage

Although scholars worldwide have made some studies on the classification of mining heritage, there is still no unified type classification system for mining heritage. The classification of mining heritage is mainly divided into five main categories and several subcategories according to the multiple attributes of mining heritage, such as natural, historical, and humanistic, as proposed in the Guidelines for the Construction of National Mine Parks in China.\(^{24}\)

The five main categories in the Guidelines for the Construction of National Mine Parks in China are listed as follows:

- Mineral geological heritage
  - Typical deposits and their geological profiles
  - Mineral search standards and signs
  - Mining water bodies and space relics
  - Geomorphology and geological landscape
    - Geological environmental changes and geological disaster relics
- Mining production heritage
  - Exploration relics
  - Extraction relics
  - Mineral processing relics
  - Smelting and processing relics
- Mining social heritage
  - Social life, religious activities sites, or relics
  - Miners’ clothing and supplies remain
  - Social customs, wedding and funeral and festive activities remain
  - Social management institutions, facilities, equipment, and related remains or relics
- Mining products remains
  - Mining products
  - Mining processing products
- Mining development documents and histories

Objects and historical documents of the discovery and exploration of
Mineral production and management concepts and systems
Objects and historical documents recording the history of the mine and
social life, human and natural changes

2.4 Main Features of Collieries Heritage

Collieries heritage, the subject of this paper, is a special kind of industrial
heritage. Its special features are not only reflected in the architectural space and form, but
also in ecological and cultural aspects. A full understanding of the main characteristics of
coal mine heritage is the basis of preservation work.

2.4.1 Environmental Issues

1) Damage to the Ecological Environment

Serious chemical attacks on soil, surface water, and groundwater cause surface
destruction and decay, damaging the mining ecosystem and reducing ecological service
functions. It causes many kinds of sudden and gradual geological disasters, including
slope deformation, landslide, and collapse caused by surface mining; ground collapse and
ground fracture caused by underground mining; landslide, mudflow, and spontaneous
combustion caused by soil discharge site and coal gangue mountain.25

2) Encroachment of Land Resources

Mining operations and mining ancillary facilities will occupy a lot of lands.
Mining causes land subsidence, forming uneven waterlogged areas, cracks, and gullies on

the surface, making a large amount of agricultural land submerged in water, or sandy and salinized. The gangue mountain, buildings, facilities, equipment, subsidiary enterprises such as coal washing plant, machine repair plant, will destroy a large number of land resources in the mine.  

3) Destruction of the Original Landscape

Because of mining, the original terrain and landscape have been greatly changed, and gradually formed a large mining collapse area and open pit, as well as coal gangue mountain. The original natural landscape has become fragmented.

2.4.2 Spatial Features

The scale of both surface and underground mines exceeds that of typical industrial heritage. Surface mines can cover a much larger area of 10-100km², and the stepped landscape created by mining is a unique highlight of later redevelopment. Underground mines account for more than 90% of China's coal mines, which are forming underground spaces with different specifications. They are divided into coal mining space, transportation space, storage space, etc., according to the different functions of the space.

Primarily, coal mining space, also known as coal mining working face, is the first production site for excavating coal, which has the regional environment of narrow space,

27 Ibid.
28 罗萍娜, 严斐. “城区型废弃矿区地下空间综合开发策略研究(Research on the exploitation strategies of the underground space in urban type abandoned mining area).” 中国矿业 3 (2019).
excessive mechanical equipment, poor visual environment, and high temperature. At present, most of the longitudinal length of coal mining face in large coal mines in China is between 1100 and 1400m, and a 3.5m diameter protective coal pillar is arranged.\textsuperscript{29} Secondarily, the transport space is generally a traffic space to connect the production space underground. These spaces are designed for pedestrian, cargo transportation, air exchange, etc. With different purposes, the minimum height of the roadway varies from 1.9m to 2.2m, and the width of the section varies from 2.5m to 10m, while the section can be trapezoidal, rectangular, or round-like. The roadway is arranged on the east or west side of the space.\textsuperscript{30} Lastly, storage spaces, also known as chambers, are underground storage and sheltering spaces, ranging from 2m to 30m in height, where large quantities of excavated coal are stored. In addition, there are also underground storage spaces, such as car parks and silos.\textsuperscript{31}

The underground space of the coal mine is arranged at different distances from the ground due to varied production needs, thus forming different spatial structures in terms of scale and depth. These mining spaces provide many possibilities for underground touring and sightseeing experiences. Setting divergent functions to spaces with different scales can provide more recreational activities when developing the reuse design.

\textsuperscript{29} 刘俊. 远郊型煤矿工业遗产再利用研究(A study on the reuse of the industrial heritage of the suburban coal mines). MS thesis. 北京建筑大学, 2020.
\textsuperscript{30} Ibid.
\textsuperscript{31} Ibid.
2.4.3 Coal Mining Culture

Coal mining heritage as a carrier of mining civilization has become an important part of cultural heritage. The cultural value of mining heritage is not only reflected in the characteristics of the heritage's features, but also in the spirit of enterprise culture and people's emotional memory. It is an important part of the city's identity.

The coal mine heritage retains a wealth of production equipment and production process elements, which are important carriers for conveying mining culture. The production equipment used by coal miners for extraction and processing in the production process, as the most direct coal mine production appliance, can directly convey the unique identification. At the same time, production equipment has diversified opportunities for interpretation when its coal mining heritage is reused.

2.5.4 Architectural Composition

Most modern coal mines after the 1950s are characterized by a large production scale and high technical level. Most coal mines not only have independent and complete coal mining production lines, including main and secondary shafts, coal storage silos, coal transportation corridors, and winch houses but also have coal refining and washing plants for producing high-quality coal. In addition, industrial office buildings, workshops, warehouses, and dormitories, halls, bathhouses, canteens and other miners' living services facilities are also fully equipped, covering most of the industrial buildings needed for coal mine production and miners' living, with strong adaptability for transformation and reuse for the implantation of various new functions.
The buildings in the mine can be broadly classified into three types according to the size and structure of the space.

1) Large-Volume Single-Story Structures

The single-story large spaces are mainly the place to accommodate large equipment or the warehouse with large storage capacity (Figure 3). These industrial buildings have large internal space, a simple building façade with skylights, and strong building structure and strain resistance. These old industrial buildings have strong feasibility for adaptive reuse. In the reuse, the original spatial form can be retained and can be transformed into such as industrial exhibition museum, large conference center, art and culture museum, exhibition and display center, etc. The large-scale trusses highlight the strong industrial aesthetics.
2) Moderate Scale, Multi-Story Structures

This kind of space is mainly for light industrial plants with small equipment and products, small product warehouses and auxiliary rooms for machine rooms. The structure of such industrial buildings is mostly frame structure, with load-bearing beams and columns that can provide flexibility for the use of space. In the renovation, they can be replaced with functions and become buildings with cultural and creative industrial clusters, which serve the daily life of the city and create an open atmosphere. These buildings have diverse potential for adaptive reuse and strong adaptability.
3) Special Structures

These special structures, such as coal selection building and shaft (Figure 4), whose structures have to meet special requirements generally possess special external form and high interior space. The structure of such buildings is stable and solid, and the interior space is enclosed as a whole. Because of its unique features and its unique structure, it can be reused to retain its original appearance to make it a landmark building.

Figure 4 Originally a large chimney of the Shanghai South Power Plant, converted into a weather signal tower for the World Expo. Source from dp.pconline.com.cn.
3 Preservation Strategies of Collieries

3.1 Two Areas

There are two main areas of research on the reuse of abandoned coal mining sites and coal mining heritage. On the one hand, there is research on strategies based on ecological restoration, and on the other hand, there is research that integrates urban, landscape, and historic preservation. These two areas complement each other and allow for the comprehensive reuse of the heritages.

3.1.1 Ecology

“Reclamation” refers to the activity of "taking remedial measures to bring the damaged land caused by mining activities to a usable state", emphasizing the restoration of land productivity and giving priority to agricultural use of the restored land.

“Restoration” is "the process of assisting degraded, damaged or completely destroyed ecosystems to return to their original development trajectory", emphasizing helping damaged land to return to its pre-damaged state.32

“Remediation” is an evolved concept based on ecological restoration. As the research progressed, scholars found that the original state of ecological restoration was difficult to determine and not feasible in practice and that the term restoration was more

scientifically accurate than restoration. With this understanding, remediation has gradually been widely used, and gradually replaced restoration.

Reclamation, restoration, and remediation are mostly based on the research objects of collapsed land and gangue-occupied mountain, and the research goal of ecological management of mining heritage, which is the basis for other regeneration of mining heritage. This is also the traditional research field of mining heritage.

3.1.2 Architecture, City Planning, Landscape and Historic Preservation

“Reuse” refers to "the use of waste directly as a product or as a product after repair, renovation, or remanufacturing, or the use of all or part of waste as a component of other products", emphasizing the continued use of waste, land resources, and used buildings, etc., and the continuation of the life of abandoned land to meet new needs.

“Redevelopment” is "the process of purchasing, demolishing, and then redevelopment", which emphasizes the redevelopment of damaged land and involves the functional replacement of abandoned land.

“Renewal” mostly refers to the landscape renewal of mining heritage. It is a way to improve the ecological environment of the site and create public space through scientific and artistic methods by transforming and reusing the natural elements of the site and its structures, buildings, machines, and other facilities through the landscape.

The concepts of reuse, renewal, and redevelopment are mostly found in the fields of urban planning, landscape design, and historic preservation. Its research objects are more extensive, including waste, subsidence, gangue crushing area and abandoned industrial plaza, etc. The objective of the research is not only ecological management but
also the further excavation of the land resource value, architectural value, landscape value, and historical and cultural value of mining heritage, especially focusing on the diversification and benefit optimization of land use of mining heritage.\textsuperscript{33}

\subsection*{3.1.3 Collieries and Urban Regeneration}

By considering the interrelated abandoned mining sites and their surrounding environment as a whole, we explore more possibilities of regeneration and utilization from a holistic perspective. In the process of regeneration of collieries, we should not only study the methods and approaches of ecological treatment but also focus attention on how to facilitate redevelopment and improve utilization, so that it can evolve into a catalyst for urban regeneration. Therefore, the regeneration of collieries involves the relationship between the land and urban regeneration.

The adaptive reuse of collieries, on the one hand, emphasizes the regenerative capacity of collieries and the importance of finding the best way to develop and utilize them; on the other hand, it emphasizes the need for a more comprehensive, integrated, and holistic perspective on the regeneration of collieries, so that they can bring new vitality to urban regeneration.

\begin{flushright}
\textsuperscript{33} 杨巍. “城市双修” 视角下矿业废弃地再生规划研究(Study of Abandoned Mine Land Regeneration under the Perspective of Urban Renewal and Ecological Restoration). Diss. 中国矿业大学 (北京), 2018.
\end{flushright}
3.2 Typical Reuse Strategies for Collieries

According to the possible categories of world heritage colliery presented in *Collieries Study*, coal mining heritage can also be broadly classified into four categories.\(^{34}\)

The four categories are as follows:

- Individual or groups of significant structures or monuments on colliery sites and adjoining colliery settlements;
- Large colliery complexes and adjoining coal-miners settlements;
- Integrated industrial areas, either manufacturing or extractive, which contain collieries as an essential part of the industrial landscape. The existing World Heritage sites of the Ironbridge Gorge and Blaenavon, both in the United Kingdom, fall into this category. The existing World Heritage sites of the Ironbridge Gorge and Blaenavon, both in the United Kingdom, fall into this category.
- Colliery landscapes, some with associated by-product processing and colliery housing and worker settlement institutions.

The pattern of adaptive reuse is also reflected in the above different scales.

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\(^{34}\) Hughes, Stephen. "COLLIERIES STUDY." *A Joint Publication of ICOMOS and TICCIH* (2002).
3.2.1 Individual Monuments

1) Museum

Changing into a museum is a common practice in the reuse of industrial heritage. First, the internal space of industrial facilities is used to permanently display industrial production processes, industrial products, industrial culture, social economy, workers’ life, and working environment, etc. Second, the industrial facilities (including the internal structure and equipment) serve as a display and transmission of industrial technology and cultural information to visitors, so that visitors can have an understanding of the industrial production process and related technical situations. Third, dynamic museums provide visitors with process experiences. For example, at the Bochum-Dahlhausen Railway Museum.

Figure 5 Bochum Dahlhausen Railway Museum. Source from erih.net.
Railway Museum (Figure 5), visitors can ride on an old steam locomotive for a real travel experience.

2) Exhibition Hall

Exhibits are displayed using the interior space, support structures, and equipment of industrial facilities. For example, the Gasometer in Oberhausen is the most spectacular indoor exhibition space in Europe, using the space-separated by the liftable air compressor tray inside the gas tank.

3) Multifunctional integrated activity center

The large space in the industrial building is transformed into a multifunctional activity center such as a conference hall, concert hall, performance hall, and movie hall.

4) Sports and leisure activities

Some large spaces will be transformed into gymnasiums. Some of the more special spaces can even be transformed into climbing gyms, etc.

5) Catering / Office

Spaces that are more modest in scale and simple in layout are often converted into dining rooms or offices.
3.2.2 Industrial Complexes: Comprehensive Utilization

Based on the preservation of integrity, the spatial potential of various facilities on the site is supposed to get fully explored and given new functions, striving to make the group buildings and facilities in the industrial plant area play a higher performance and realize comprehensive utilization. For example, cultural and creative industrial parks, commercial shopping centers, etc.

3.2.3 Industrial Sites: Landscape park

This refers to the combination of the preservation of industrial heritage with the renewal and organization of industrial landscape, the integration of spatial components, the restoration and remediation of ecological environment, and the combing of a
transportation system to create an industrial landscape park with composite functions such as industrial culture tour, leisure, entertainment and sports. In other words, this kind of industrial tourism landscape generally includes three forms: public landscape space, urban theme park, and urban square. Typical cases include Germany's "North Duisburg Landscape Park", Bochum's "City West Landscape Park", Gelsenkirchen's "Nordstern Landscape Park" and so on.\(^{35}\)

3.2.4 Preservation with Larger Regional Context

1) Conservation and Reuse of Industrial Towns

For example, the German mining town of Goslar and the British industrial town of Blaenavon can adopt the measure of adaptive reuse to preserve the unique character of the town and gradually develop appropriate tourism through planning and policies, in order to pass on historical culture, promote cultural exchanges, enhance the town's popularity and reputation, and enhance commercial vitality.

2) Protective Reuse of Regional Industrial Heritage

It refers to the overall development and utilization of industrial heritage within a certain area under a unified framework. A representative example is the Industrial Heritage Route (RI) in the Ruhr region of Germany. The Ruhr region is one of the largest industrial city clusters in the world, with a large number of similarly sized industrial

\(^{35}\) 刘挺英, 邹涛, and 蒋德祥. “德国鲁尔区工业遗产保护与再利用对策考察研究(Study on the conservation and reuse of industrial heritage in the Ruhr region of Germany).” 世界建筑 7 (2007): 120-123.
towns linked by highways and distributed homogeneously across the regional space, with industrial heritage scattered among them. The Industrial Heritage Route connects the industrial heritage nodes through the tour route, forming a spatially integrated view of the industrial heritage in the region.

4 Mining Cities

In exploring the preservation of collieries, we should not speculate on its meaning, but rather place it in the most typical and possible scenarios of its application. Most of our coal mines were excavated and mined in the 20th century. The mining of coal resources has inevitably been accompanied by a gradual concentration of labor, assets and other resources, which has led to the formation of coal mining cities. The depletion of resources also brought about the decline of coal mining cities. Most of our existing coal mining heritages still exist in these coal mining cities, and the two are inextricably linked. Therefore, coal mining cities as the typical scenario to be explored in this paper, to study the role of the preservation of collieries in the urban regeneration of coal mining cities, it is inevitable to understand clearly the current situation of these cities in China, as the most important branch of mining cities.

4.1 Mining Cities

Mining is an industry that explores, extracts, exploits, and processes mineral resources, from the earth for humans used as a source of energy. A mining city is a city that has emerged or grown as a result of the development of mineral resources and where
mining occupies a dominant or leading position in the city's industrial structure over a period of time.\textsuperscript{36}

\subsection*{4.1.1 Mining Cities in China}

Since the emergence and development of mining cities are inextricably linked to "mining", mining cities are fundamentally different from general cities. For Chinese mining cities, the rise and fall of mining have shaped that of urban development of the cities. Additionally, Chinese mining cities have emerged suddenly, because most of them were formed in a special industrialization background and were developed under traditional planned economic. In the 1950s, the early industrialization of the country urgently required a large amount of energy and mineral resources, which led to a large number of laborers, materials, and financial resources gathering in mining areas. As a result, mining cities rose rapidly. Additionally, the development of these mining cities was highly dependent on the government, and the country’s control over the resource industry and economic policies largely determined the fate of mining cities.

Therefore, once losing their resources and policy advantages, most mining cities will immediately fall into a development dilemma. Besides, mining cities generally lack favorable location conditions and satisfying infrastructure. The city's openness is generally low, and the pace of opening up and attracting investment is far behind the national average. At the same time, the environment tends to deteriorate, which also brings great problems to the development.

\textsuperscript{36} 宋新. 矿业城市空间结构演变过程与机理研究(Study on Progress and Mechanism of Urban Spatial Structure of Mining City). Diss. 长春: 东北师范大学, 2008.
4.1.2 Types of Mining Cities

According to different characteristics, mining cities can be divided by different methods, and the current domestic research can be basically summarized into the following three methods:

- According to the mineral resources that the city depends on, it is divided into oil city, coal city, non-ferrous metal city, metallurgical city, chemical city and comprehensive mining city.

- According to the causes, they are classified into non-dependent mining cities and dependent mining cities. Non-dependent mining cities are those emerged due to mining development but without original cities; dependent mining cities are those that originally had cities, and then developed and grew due to mining development in nearby areas.

- According to the degree of mining development and the development stage of the city, it is divided into the growth period, the peak period and the decline period.

4.1.3 Geographic relationship between mining cities and mining areas

The geographic relationship between mining cities and mining areas can be divided into three typologies: Combined Urban Mine, Mining City, and Independent Mining Complex. 37

1) Combined Urban Mines

37 宋晓. 矿业城市空间结构演变过程与机理研究(Study on Progress and Mechanism of Urban Spatial Structure of Mining City). Diss. 长春: 东北师范大学, 2008.
The administration of the main mining enterprise is located in a more developed city. The operation system of the main enterprise is distributed near or in the city, and the mining area has a corresponding community government that performs some of the functions of management. Miners live around mining areas which gradually form residential areas. For example, the Xuzhou mine in Jiangsu.

2) Mining Cities

A city with obvious mining characteristics gradually developed on the basis of a mining area, and the main enterprise of the city is also the main enterprise of the mining area. For example, Huainan in Anhui is a city that has gradually developed on the basis of coal mining, and the industrial mining structures tend to define the city and its characteristics.

3) Independent Mining Complexes

The mining area basically exists independently, far from the central city, with the corresponding government to exercise the social management functions of the mining area. These mines are far away from the cities, and relatively independent, most of which will be abandoned soon after the depletion of resources.
4.2 Coal Mining Cities

Coal mining cities are cities that have gradually developed due to the local mining of coal resources or reemerged due to the nearby mining of coal resources, and where the coal industry occupies an important position in the industrial structure. Coal cities are the largest and most numerous types of mining cities in China.

4.2.1 Status of China's Coal Mining Cities

Most of China's coal mining cities were formed in the 1950s, and the development of coal mining cities experienced three peak periods of development, the
1950s, the 1980s, and the end of the 20th century, with the scale and number of cities increasing continuously. However, the trend of coal resource depletion has become more obvious due to the wastefulness caused by a large amount of mining and rough mining methods in the early stage. The development of the coal industry in these cities has gradually shown its drawbacks, thus, many forward-looking cities have begun to actively seek transformation. At present, there are 65 coal mining cities in China, of which there are 34 prefecture-level cities, 21 county-level cities, 2 counties, and 8 municipal districts. China's coal mining cities are geographically concentrated in the three regions of Central Plains, Northeast China, and Huaihe River Basin, distributed in 22 provinces and regions, among which Shanxi, Inner Mongolia, and Henan provinces have the most coal cities. The geographic distribution of coal mining cities in China is basically consistent with the underground reserves of coal resources, and a few coal-rich areas have not formed large coal city clusters due to the lack of in-depth exploration and high engineering requirements for good construction.

At present, more than 1/3 of coal cities in China are in the decline period. With the depletion of mineable coal resources, the coal industry continues to decline and cities are beginning to transform, with leading industries gradually being replaced by other non-coal industries.

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4.3 Urban Regeneration in China’s Coal Mining Cities

The purpose of urban regeneration is to transform areas of the city that are no longer able to adapt to the urban development process, so that they can flourish again, which is divided into two parts: the transformation of the architecture and the transformation of the ecological and cultural space environment. The theory of urban regeneration refers to the renovation and design of declining and unused areas in the city in order to rejuvenate the area.
4.3.1 Main Methods of Urban regeneration

There are three main approaches to urban regeneration.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Main content</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-construction</td>
<td>Demolition of buildings in the area and development of new uses for the site</td>
<td>The overall spatial environment has changed, and its social dimension has also changed</td>
</tr>
<tr>
<td>Comprehensive Management</td>
<td>Overall renewal design with the surrounding environment and the buildings in the area</td>
<td>Improve and upgrade public service facilities and infrastructure in the region, as well as environmental management, etc.</td>
</tr>
<tr>
<td>Change function</td>
<td>Change the original use function according to the new business needs</td>
<td>Displaces the functions of the buildings in the area and the surrounding environment</td>
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Table 1 Main methods of urban regeneration.

4.3.2 Urban regeneration Model in Coal Mining Cities

Since the 1980s, with the development of economic globalization and the rapid advancement of the market economy, the overall social operation system in China has undergone a drastic transformation. Urban space has been rapidly reconfigured, and the manifestations include rapid expansion of external space and internal spatial restructuring. Since urban land resources are limited and there is an inherent contradiction between urban expansion and land resources, urban regeneration faces an inevitable transition from renewal of existing to the renewal of increment. The urban regeneration modes in the renewal of the existing period mainly include the following three types.

1) Real-Estate Led Urban Regeneration Model

During the transition from a planned economy to a market economy, real estate development-led urban regeneration has long been a dominant mode of renewal in China, as it can effectively drive economic growth in the short term and become an important contributor to the improvement and development of China's urban landscape. With the development and expansion of cities, the construction of new development zones, the guidance of urban planning policies, and other reasons, some companies' plants went bankrupt and closed down, or moved out, and all the original industrial plants were demolished and new residential communities were established, completely changing the face of the industrial factory areas.

2) "Culture+" Led Urban Regeneration Model

"Culture-plus" urban regeneration is an integrated urban regeneration strategy that includes culture, art, and design retail. This urban regeneration model has gone through a process of development and change. The early "culture-plus"-led urban regeneration activities were to provide new vitality to the urban area by giving the heritage a cultural connotation and replacing it with functions such as entertainment, dining, and art. Subsequently, the use of cultural power to reshape the city's image through large-scale flagship projects became a means to stimulate urban vitality, and also became the mainstream of culture-led urban regeneration. These flagship regeneration projects generally include retail regeneration of large thematic shopping plazas, redevelopment of large iconic venues, construction of new urban landmarks, and other large-scale

regeneration activities that tap into the original cultural heritage and historical connotations of the city.\textsuperscript{41}

3) Industry Upgrading and Transformation-led

Industrial upgrading and transformation are also a new driving force for the renewal of coal mining cities. Industries that do not fit into the inner-city development plan will be relocated or renovated, and the original factories will have to be adapted, which will lead to the development of new industries and new functions, thus stimulating the regeneration of the area.

4.3.3 Adaptive Reuse of Collieries and Urban Regeneration

The preservation of coal mining heritages can be applied to several urban regeneration models mentioned above, except for the real estate-led model, which uses reconstruction as the main means.

In particular, the preservation of coal mining heritages is more valuable for the function-replacement-led regeneration model because of its rich and special material and cultural heritage. Several common types of regeneration, such as coal mine themed museums, cultural theme parks, and commercial complexes based on coal mine heritage, are all common functional replacement-oriented urban regeneration. Through functional replacement, coal mining heritage can generate new vitality and stimulate the economic development of old mining areas and old industrial areas in cities, thus promoting urban regeneration.

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5 Strategies for the Adaptive Reuse of Collieries: Jiaozuo as an Example

Jiaozuo is one of the traditional industrial cities in China, and the development of the city is closely related to industrial production. Jiaozuo is rich in mining heritage resources, and its mining heritage is rich in types and well preserved in its current state, with strong reusability. As one of the major coal production areas in modern China, Jiaozuo's coal industry had played a significant role in China's modern industrial history and greatly promoted the development and construction of the city.

In 2013, the National Sustainable Development Plan for Resource-based Cities (2013-2020) made clear plans for 262 resource-based cities in terms of development direction, resource utilization, industrial development and environmental protection. The document identifies 69 cities in the resource depletion stage, and Jiaozuo is among the list. As a typical mining city in decline, studying the role of preserving coal mining heritage on Jiaozuo's urban regeneration can help provide development ideas for other cities, which is why Jiaozuo was selected as a subject in this study.

5.1 Location

Jiaozuo City is located in the northwest of Henan Province, bordered by Taihang Mountains in the north, Jincheng City in Shanxi Province, the Yellow River in the south, Zhengzhou and Luoyang, Xinxiang in the east, and Jiyuan in the west. Jiaozuo has four districts, namely Jiefang District, Shanyang District, Zhongzhan District, and Macun District, one demonstration zone for urban-rural integration (High-tech Development Zone) and six counties (cities), namely Xiuwu County, Wuzhi County, Wen County,
Boai County, Qingyang City and Mengzhou City, with a total area of 4,072 square kilometers, a resident population of 3,640,400 and an urbanization rate of 48.8%.

5.2 History and spatial development

From 1898 to 1949, with the coal mining in Jiaozuo by the Anglo-French Company, the urban population increased, and Jiaozuo coal mine jumped to become the third-largest coal mine in China. The completion and opening of the Daoqing Railway stimulated the development of industry and commerce along the railroad line. From 1949 to 1956, the output of Jiaozuo coal mine gradually rose, and Jiaozuo mining area became Jiaozuo City, marking the basic formation of a resource-based city.42

Jiaozuo developed gradually by relying on the mining area, and its spatial form was typical of a mining city. Residential areas, commercial areas, schools, and hospitals

42 赫媛媛. 因煤而兴: 焦作城市空间的形成与扩展 (1898-1956)(Rising with coal: the formation and expansion of Jiaozuo’s urban space). MS thesis. 天津师范大学, 2018
were built around the mine. The city's living and industrial areas were mixed, thus ensuring maximum production efficiency. The economic level and technical conditions of cities in this period were still immature, and the natural geographical conditions had stronger restrictions on urban spatial development, and urban spatial expansion was limited by rivers and railways. The cities in this period were small in scale and slow in expansion.\footnote{赫媛媛. 煤烟而兴: 焦作城市空间的形成与扩展 (1898-1956)(Rising with coal: the formation and expansion of Jiaozuo’s urban space). MS thesis. 天津师范大学, 2018}

In 1957, Jiaozuo broke through the monocentric development model by building towns on the east and west sides of the old city, which were linked by railroads and highways to form a decentralized development spatial structure of "one city and two towns". During this period, Jiaozuo's urban construction was so fast that the built-up area expanded nearly 10 times, and the spatial form expanded from the initial point-like to surface-like. The industrial area, living area, education and medical area of the city were still mixed, and the functional zoning was not obvious. The green space in the city began to increase, and the urban environment was greatly improved; the road system was continuously improved, and the road network was formed.\footnote{郭勇秀, 焦作工业遗产城市的保护与发展策略研究(Research On The Protection And Development Strategy Of Industrial Heritage City Jiaozuo). MS thesis. 东南大学, 2018}

In 1999, Jiaozuo started to decline. The city began urban transformation with tourism as a breakthrough, realizing the transformation from a coal city to a tourist city. A high-tech industrial development zone was built in the south of the city, forming a double core structure with the old city. The heavily polluted industrial land was gradually moved to the industrial clusters on the periphery of the city, and most of the internal
industrial land was changed into modern residential and urban commercial areas. Additionally, series of urban theme parks have been built to restore the ecological environment and increase the greening rate of the city, taking advantage of the good natural environment of the northern mountains and the mining collapse areas of the city.\textsuperscript{45}

With the rising land price in the central city and the strengthening of urban planning and environmental protection, a large number of industrial enterprises located in the old city have been relocated to the suburbs of the city. Although the Wangfeng and Lifeng coal mines have long ceased production, the industrial heritage such as equipment, plants, and ancillary facilities are well preserved and of high value. The preservation and utilization of this coal mining heritage coincide with the goal of transforming the city of Jiaozuo into a tourist city.

\begin{flushright}
\textsuperscript{45} 鄭冷秀. 焦作工业遗产城市的保护与发展策略研究(\textit{Research On The Protection And Development Strategy Of Industrial Heritage City Jiaozuo}). MS thesis. 东南大学, 2018.
\end{flushright}
Map 2 Jiaozuo City in 1922. Map created by the author based on the map data from 360doc.cn.
Map 3 Jiaozuo City in 1956. Map created by the author based on the map data from 360doc.cn.

Map 4 Jiaozuo City in 1992. Map created by the author based on the map data from 360doc.cn.
## 5.3 Existing Coal Mining Heritage in Jiaozuo

<table>
<thead>
<tr>
<th>Name</th>
<th>Built Year</th>
<th>Current Status</th>
<th>Designation</th>
<th>Current Use</th>
<th>Ownership</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>军调处新乡执行小组谈判旧址 The former site of the Jiaozuo negotiations of the Xinxiang Executive Group of the Military Reconciliation Office</td>
<td>1911-1949</td>
<td>Good</td>
<td>Municipal Cultural Relics Protection Unit</td>
<td>Commerce</td>
<td>Coking Coal Group</td>
<td>Formerly the head office of Zhongyuan Coal Mining Co.</td>
</tr>
<tr>
<td>焦作煤矿工人罢工指挥部旧址 The former site of the Jiaozuo Coal Miners’ Strike Command</td>
<td>1911-1949</td>
<td>Good</td>
<td>Municipal Cultural Relics Protection Unit; The first batch of national industrial heritage</td>
<td>Education</td>
<td>Henan Polytechnic University</td>
<td>Originally the office of the secretary of The Peking Syndicate, later it was used by the Jiaozuo Road Mining School and in 1925 it was the command center of the Jiaozuo coal miners’ strike.</td>
</tr>
<tr>
<td>焦作卢公司职员住宅 The Peking Syndicate Company Staff Residence</td>
<td>1898-1911</td>
<td>Fair</td>
<td>Provincial level cultural relics protection unit</td>
<td>Residence</td>
<td>NO.1 Middle School Jiaozuo</td>
<td></td>
</tr>
<tr>
<td>焦作卢公司煤业遗址 The Peking Syndicate Company Coal Mining Site</td>
<td>1898-1911</td>
<td>Good</td>
<td>Provincial level cultural relics protection unit; The first batch of national industrial heritage</td>
<td>Residence, Office</td>
<td>Coking Coal Group</td>
<td>Existing No.1 and No.2 shaft platform and derrick, No.3 shaft platform and derrick</td>
</tr>
<tr>
<td>焦作卢公司电机房旧址 The former site of the motor house of The Peking Syndicate Company</td>
<td>1911-1949</td>
<td>Good</td>
<td>Provincial level cultural relics protection unit; The first batch of national industrial heritage</td>
<td>Industrial and agricultural production</td>
<td>Coking Coal Group</td>
<td></td>
</tr>
<tr>
<td>焦作卢公司电工房旧址 The former site of the electrician’s room of The Peking Syndicate</td>
<td>1898-1911</td>
<td>Good</td>
<td>Provincial level cultural relics protection unit; The first batch of national industrial heritage</td>
<td>Industrial and agricultural production</td>
<td>Coking Coal Group</td>
<td></td>
</tr>
<tr>
<td>焦作卢公司总办事处旧址 The Peking Syndicate’s former head office</td>
<td>1911-1949</td>
<td>Good</td>
<td>Provincial level cultural relics protection unit; The first batch of national industrial heritage</td>
<td>Educational</td>
<td>Henan Polytechnic University</td>
<td>Including the main house and supporting rooms</td>
</tr>
<tr>
<td>焦作卢公司李封矿矿师办公室旧址 The Peking Syndicate’s former division office</td>
<td>1898-1911</td>
<td>Good</td>
<td>Municipal Cultural Relics Protection Unit</td>
<td>Industrial and agricultural production</td>
<td>Coking Coal Group Lü Feng Mine</td>
<td></td>
</tr>
<tr>
<td>焦作卢公司王封井 The Peking Syndicate’s Wang Feng Mine Shaft</td>
<td>1919</td>
<td></td>
<td>Municipal Cultural Relics Protection Unit</td>
<td>Industrial and agricultural production</td>
<td>Coking Coal Group</td>
<td></td>
</tr>
</tbody>
</table>

*Table 2: Existing coal mining heritages in Jiaozuo (before 1949). Table created by the author based on Jiaozuo City Heritage Records and Guo Lengxiu (2018).*
The relevant heritage before 1949 is mainly the remains of the Peking Syndicate Company and Zhongyuan Company, which are fewer in number and scattered in spatial distribution. The industrial heritage of this period not only shows the appearance of the earliest industrial area of the city but also reveals the characteristics of the urban origin of Jiaozuo.

<table>
<thead>
<tr>
<th>Name</th>
<th>Built Year</th>
<th>Current Situation</th>
<th>Designation</th>
<th>Current Use</th>
<th>Ownership</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhu Cun Mine</td>
<td>1955</td>
<td>Good; 2016 Discontinued operations</td>
<td>N/A</td>
<td>Vacant</td>
<td>Coking Coal Group</td>
<td>Auditorium, office building, reception room, coal washing building, sedimentation pond, power distribution room, winch room, mine, coal silo, dispatching building, boiler room, repair room, batching workshop, brick making workshop, desulfurization tower</td>
</tr>
<tr>
<td>Wang Feng Mine</td>
<td>Established in 1919, the main production plant and living space was built after the 1950s</td>
<td>Fair</td>
<td>N/A</td>
<td>Industrial</td>
<td>Coking Coal Group</td>
<td>Warehouse, residence, electromechanical workshop, office building, vertical shaft, coal washing building, hospital, canteen</td>
</tr>
<tr>
<td>Li Feng Mine</td>
<td>1916, built after the founding of the country except for the division office of the Li Feng Mine</td>
<td>Fair</td>
<td>N/A</td>
<td>Industrial</td>
<td>Coking Coal Group</td>
<td>Bathroom, workshop, office, warehouse</td>
</tr>
</tbody>
</table>

Table 3 Existing coal mining heritages in Jiaozuo(1949). Table created by the author based on Jiaozuo City Heritage Records and Guo Lengxiu(2018).

Most of the heritage after 1949 was built in the early period of the founding of the People's Republic of China, and the history of Wang Feng Mine and Li Feng Mine can be traced back to the 1920s. The heritage after 1949 is better preserved in its present state, and the industrial buildings are concentrated in pieces, which can completely reflect the
whole picture of coal industry production. Now the main surviving ones are Li Feng Mine, Wang Feng Mine, Zhu Village Mine, etc.

5.4 Value Analysis

5.4.1 Historical Value

Jiaozuo has a number of well-preserved coal industry buildings and structures with a complete pattern. Among them, Jiaozuo Zhongfu Coal Mine was included in the first batch of China's industrial heritage protection list. Zhongfu Coal Mine was one of the four largest foreign-funded coal mines in China that used machines to produce coal in modern times and ranked third in coal production in China after Kailuan and Fushun. The main remains include the No. 2 shafts and derrick house; the No. 3 shaft and supporting buildings; the motor house; the office of the main office; the hospital; the movie theater; the coal miners' strike headquarters; the powerhouse; and the motor and winch equipment.

The existing industrial heritage of Jiaozuo is the actual evidence of the beginning of China's modern coal industry history, which is of great historical significance. At the same time, Jiaozuo is a typical representative of China's modern urban industrialization and modernization transformation: in 1898, the British mining company Foo adopted the house-pillar coal mining method, which was the first Western coal mining method introduced to Henan. The development of the mining industry led to the construction of a number of large municipal public infrastructures that were related to the people's livelihood. As an important source of coal, a number of large-scale transportation facilities were built to connect with the outside world, such as Jiaozuo North Station and
Daoqing Railway. Jiaozuo became the first city in Henan Province to use electric lights and running water. At the same time, it also led to the development of Jiaozuo's education and medical services.

Jiaozuo's coal mines have experienced the economic transformation periods of the foreign affairs movement at the end of the Qing Dynasty, the construction of the at the beginning of New China, and the reform and opening up. The heritage of the coal mining industry has gone through a process from scratch, creating a glorious history and finally going into decline. This process of ups and downs condenses the history of Jiaozuo from the history of China's colonial invasion, the history of China's revolutionary development, and the history of New China's construction, and the coal mining industrial heritage of Jiaozuo in different periods has preserved the evolutionary characteristics of the corresponding historical periods, which has become an indelible historical mark.

5.4.2 Cultural Value

Jiaozuo's coal industry was a national leader in the modern period, and its two regional migrations brought advanced coal production technology and management concepts to Sichuan, Hunan, and Shanxi, which effectively promoted the development and progress of coal technology. Jiaozuo's coal was of good quality and high yield, and most of it was exported to support industrial production in eastern cities, which had made great contributions to the industrialization of China in the early years of the founding of the country. The prosperity of Jiaozuo's coal industry also led to the development of other industries such as machinery, electricity, medical education, etc. The industrial heritage preserved to this day reflects the achievements of industrial construction in various
periods of Jiaozuo's urban development, with distinctive characteristics of the times and industrial landscape.

For a long period of time, China's planned economy was dominated by the state's unified management of enterprises, which at the same time also assumed many social functions such as kindergartens, primary and secondary schools, hospitals, and cinemas. In addition, the spatial form and texture of the city, which was "built by coal", were greatly influenced by the act of coal mining. Production plants, production equipment, and mining culture have all been marked by the industrial era and the region, giving these coal mining cities a unique sense of cultural richness. The modern industrial heritage group of Jiaozuo City is not only the epitome and living fossil of the modern industry in the Central Plains. Jiaozuo's industrial heritage is highly reusable, and its conservation and reuse are of great social and practical significance in promoting local economic and cultural development.

5.4.3 Economic Value

To upgrade and transform Jiaozuo's traditional industries, cultural and creative, boutique tourism and other service industries are one of the priorities for development. In the industrial mapping, the old city where Jiaozuo's coal mine heritage is located should be used as a key demonstration area to promote urban regeneration and give new vitality to the old city.

The coal mine heritage in the old city is located in the urban area and the near suburbs of the city. With convenient transportation, it should be reused with its location advantage to develop reasonable commercial space or tourism and leisure projects,
enhancing the consumption potential of the city, creating a city brand, further promoting urban regeneration and urban transformation, and promoting urban economic development.

The preservation and renewal of Jiaozuo's coal mining heritage can provide space to meet the needs of the city's industrial transformation and improve supporting services and facilities, in line with Jiaozuo's development needs.

5.4.4 Natural Value

The abandoned land of coal mines in Jiaozuo, such as the subsidence area of the Yanmazhuang mine, has been damaged by the structure of underground aquifers due to coal seam extraction and land subsidence. Ground subsidence and ground fissures cause land and farmland to be divided and destroyed, affecting cultivation and preventing crops, trees and vegetation from growing normally. A large amount of slag and gangue not only occupy the land, but also destroy the vegetation resources. There are 18 such ground collapse pits in Jiaozuo City, with a total collapse area of about 51.6km². By preserving such abandoned land, effectively improving the ecological environment, coordinating with the surrounding environment, creating a complete ecosystem, creating an urban green space with regional characteristics, and realizing its due natural values.46

5.4.5 Aesthetic Value

As the coal industry is centered on the production process throughout the industrial area planning, architectural design and public areas, it has formed a large volume of industrial heritage buildings with rich forms and different shapes. The combination of the massive industrial area and the local customs has created a unique industrial landscape in the city, which has become the most characteristic symbol of the city. Chronologically, due to its long history, the buildings within Jiaozuo's coal mining heritage have characteristics of the Qing Dynasty, the Republic of China period, and after the founding of New China. Spatially, due to the period of war, it has the architectural styles of China, England and other countries. The coal mine heritage has traces of both local and foreign cultures, and has an "eclectic" national style with significant artistic value.
## 5.5 Case Studies of Mining Heritage for Urban Regeneration

<table>
<thead>
<tr>
<th>Reuse method</th>
<th>Location</th>
<th>Case Study</th>
<th>Primary Takeaways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological improvement</td>
<td>Urban</td>
<td>Tangshan South Lake National Urban Wetland Park</td>
<td>The original mining collapse area was ecologically improved and upgraded, and is now used as an ecological recreation area for citizens</td>
</tr>
<tr>
<td>Insert display function</td>
<td>Urban</td>
<td>Weifangfangzi Charcoal Mine Museum</td>
<td>Reproduces the coal production of the former Fangzi Charcoal Mine through a variety of displays.</td>
</tr>
<tr>
<td>Integrated commercial development</td>
<td>Urban</td>
<td>Germany Oberhausen Center Shopping Area</td>
<td>Relying on the original production plant, it was transformed into a consumer complex that attracts weekend visitors from the Netherlands and other places for shopping, leisure and vacation</td>
</tr>
<tr>
<td>Ecological improvement</td>
<td>Suburban</td>
<td>Liaoyuan National Mine Wetland Park</td>
<td>Plays a vital role in the improvement of the regional ecological environment</td>
</tr>
<tr>
<td>Agricultural economic cultivation</td>
<td>Suburban</td>
<td>Shuozhou Taibao Open Pit Mine</td>
<td>Set up vegetable greenhouses, forage bases, Chinese herbal medicine bases and afforestation bases in the mining area</td>
</tr>
</tbody>
</table>

*Table 4 Case studies of mining heritages.*
5.6 Basic Principles

Based on some theoretical foundations of historic preservation, existing research on the reuse of coal mining heritages, relevant cases and future development goals, four relatively general principles are summarized.

5.6.1 Integrity

The principle of integrity is the primary principle for the preservation and reuse of industrial heritage. The conservation of industrial heritage in Jiaozuo City should not only protect the integrity of the heritage itself and its historical environment, but also consider the relationship between the coal mining heritage and the surrounding architecture and urban environment, so that it can be integrated into the modern urban environment.

5.6.2 Authenticity

The principle of authenticity means to preserve the coal mining heritage in its true state and the historical information that exists. The restoration and reuse of heritage should be treated with caution and on the premise that no secondary damage will be caused to the heritage.

5.6.3 Sustainability

The principle of sustainable development is to consider the relationship between conservation and development in an integrated manner, to focus on rationality and science, and to achieve sustainable economic and social development through rational
use. Sustainable development not only means that the industrial heritage can move forward and take on new urban functions, but also means that part of the heritage can be restored to its original productive functions if necessary.

5.6.4 Multi-party Cooperation

The principle of multi-party cooperation means that the conservation of heritage requires the participation of multiple disciplines and subjects in research and practice, and Jiaozuo City should keep an open attitude towards this and jointly promote the development of mining heritage conservation.47

5.7 Strategies

Just as the strategies in the previous study were divided into different levels, from individual heritages to industrial cities, thus in the development of relevant strategies for Jiaozuo, attempts are made to propose different levels from individual mine preservation to urban identity construction. This is what is advocated in the conservation work, not only focusing on the coal mining heritage itself, but also integrating it into the city's cultural fabric, and then creating possibilities for urban regeneration.

5.7.1 Reuse of individual coal mining sites – Based on Zhucun Mine in Jiaozuo

1) Overview of Zhucun Mine

Zhucun Mine is the first new medium-sized mine of Jiaozuo Mining Bureau, which was built in 1955, put into production on July 1, 1958 and was completely shut down in 2016. Located 5km from the old city of Jiaozuo, it is named Zhucun Mine because most of the shaft field is in North Zhucun.

The mine is bounded by the Jiaozuo Ecological Botanical Garden to the north, the Forest Park (with a zoo inside) to the east and the main city road to the south. The surrounding area as a whole is dominated by suburban rural landscape, with a relatively outdated urban construction and the existence of a large amount of non-construction land.

The topography of the mine is high in the north and low in the south, with an area of 6.9 square kilometers in a narrow rhombus shape and an industrial area of about
200,000 square meters, which was the key production mine of Jiaozuo Mining Bureau that once ranked first in production.

The Zhucun mine is currently idle and its main production area now belongs to Xinzhuchun Industry Co.

Referring to the division of Jiaozuo protection zone in Research On The Protection And Development Strategy Of Industrial Heritage City Jiaozuo, the protection
of Zhucun mine zone is divided into three levels, including the core preservation area, the secondary preservation area, and the landscape preservation area.

2) Reuses Strategies

Jiaozuo City itself attaches considerable importance to the reuse of local industrial heritage as an important channel for urban regeneration. For example, the city uses two 100-meter-high and 50-meter-wide drying water towers of Jiaozuo Power Plant combined with light and shadow, water special effects and stage performances to create a towering live-action performance cultural tourism project with a total investment of 500 million yuan.

However, none of Jiaozuo's individual coal mine heritage is currently being exploited on a large scale. The newly built Xidajing 1919 Cultural Tourism Park (former Jiaoxi Mine) is the only coal tourism project. The first phase of the park is divided into several functional groups, which are the core area of Jiaozuo Coal Miners' Strike Memorial Hall, the special commercial street group, the cultural and creative group, and the enterprise management office group. However, the actual development and management level of the project is low, and it has been turned into a low-end commodity trading market.

The urban context of Jiaozuo gives the possibility for the overall development of the Zhucun mining area.

As there is a large amount of undeveloped land in the Zhucun mine area, it is overall very suitable for the regional development as a whole, with coal-related themes as the core, developing leisure and vacation, theme exhibitions and other related tourism industries.
The Zhucun Mine is adjacent to the Botanical Garden to the north and the Ecological Park (Zoo) to the east, but the overall facilities are outdated. The ecological park and botanical garden are large in area, but the development area is small (Figure 9). Therefore, a mature ecological landscape urban park can be developed in combination with the landscape features of the whole area, together with the coal-themed tourism park (including museums, experience museums, etc.) and related resort industry development (e.g. hotels, restaurants, etc.).

The existing railroad line (Daoqing Railway) is abundant in Zhucun mining area, and Lianchen River passes through the inner part of the area. Therefore, first of all, the ecological restoration and utilization of the collapse area should be dealt with, and the

Figure 9 Current landscapes in Zhuncun Area. Photo by the author.
railway line can be partially expanded to form a special train excursion road through the area together with the original railway line. The main road near one side of the railway line can be designed for traffic, while other roads in the area are designed in the form of country roads. According to the river, relevant excursion routes can also be set.

Through the overall planning, the Zhucun mine area will be used as a breakthrough point to build a coal-themed tourism resort, improve the vitality of Jiaozuo city, and promote the development of the city's related tourism industry as well as urban regeneration.

5.7.2 Jiaozuo Industrial Heritage Corridor

The individual utilization of each mine area is the core point, connecting these points into lines and lines into districts to further promote urban heritage preservation work for urban regeneration.

Taking the existing Wangfeng mine Lifeng mine area, Zhucun mine area and the coal mine heritage of the unformed area as a whole, a coal mine heritage corridor at the municipal level is constructed, forming a reuse preservation area with various projects on a district basis.

From Jiaozuo city as a whole, the aim is not only to build a single coal-themed tourist attraction, but to connect the entire city's industrial heritage area and create an industrial tourism city brand.

Jiaozuo is a typical industrial city in the central region. The city has retained a large number of industrial heritages of different historical periods, which are rich in types, well preserved and connected into patches. From the perspective of the city's
historical development, Jiaozuo's urban space has good historical continuity. The spatial relationship between industrial land and the surrounding functional land and traffic areas has remained basically unchanged.

The existing urban space, especially the industrial heritage area, can better reflect the early spatial form of the city. This is a special feature of Jiaozuo, and a rare example in China. The main industrial heritage areas in Jiaozuo are concentrated along the Daoqing Railway, and the six key areas cover the major industrial heritage from the late 18th century to the present.

Therefore, in linking the key areas of Jiaozuo, an industrial landscape green corridor can be built along the railroad that runs east and west through the city,
connecting the scattered industrial heritage areas on both sides into a whole and constituting an industrial cultural axis in the urban space of Jiaozuo.

5.7.3 Linking City Clusters in The Province

As a medium-sized city with a resident population of about 3.6 million, Jiaozuo's intra-city consumption capacity is somewhat limited compared to that of larger cities. Therefore, the promotion of urban regeneration in Jiaozuo should not only be limited to the internal part of the city itself, but also take full advantage of its rich heritage and good location to develop the provincial and domestic tourism market.

Jiaozuo, as a sub-core city of Zhengzhou (capital of Henan Province) metropolitan area, is only 90 kilometers away from Zhengzhou City, one and a half hours by car and 40 minutes by high-speed rail. The Henan Provincial Urban System Plan (2011-2020) mentions the implementation of the central city-driven strategy, focusing on the construction of the Central Plains City Cluster with Zhengzhou and Luoyang as the center, promoting the integrated development of Jiaozuo with Zhengzhou, Kaifeng, Xinxiang and Xuchang, and building the modernized Zhengzhou Metropolitan Urban Area.

The reuse of Jiaozuo's coal heritage can create Jiaozuo's industrial heritage tourism brand, promote the construction of Jiaozuo coal culture tourism city, and thus truly help Jiaozuo out of the development dilemma, and facilitate the regeneration of the city.
6 Conclusion

This paper discusses the role of coal mining heritage preservation and reuse in promoting the urban regeneration of declining mining cities, starting from two aspects: the main characteristics and preservation methods of coal mining heritage and the current situation of Chinese mining cities. Meanwhile, taking Jiaozuo city as an example, the conservation and reuse methods of coal mining heritage in Jiaozuo city in the context of urban transformation are studied from the relationship between urban development and industrial development in Jiaozuo city, hoping to further promote urban regeneration and urban transformation development strategies.

As a special kind of industrial heritage, coal mine heritage not only has various architectural forms, but also is inseparable from ecological environment and natural landscape and other elements. The reuse of coal mine heritage should not only deal with the ecological damage, but also make full use of the relationship between coal mine heritage and the city, and fully stimulate its vitality. The reuse can be divided into individual units, complexes, landscapes, and larger urban scales. The reuse of heritage is not only related to itself, but also to the larger context.

At this stage, there are many problems in the transformation and development of mining cities in China, which need further in-depth study. Through the study of Jiaozuo, it can be found that the key to urban regeneration lies in the upgrading and transformation of leading industries. The economic, social, environmental, unpreserved heritages and other series of problems that appear in the process of industrial city development are all the accompanying results of urban industrial development. Only by solving the problem of industrial transformation, can other problems be addressed. Development of urban
infrastructure is integral to the transformation. Urban transformation requires the city to provide good roads, infrastructure, service facilities and other conditions. Making good use of the existing coal mine heritage is an important breakthrough for urban regeneration and industrial transformation.

Due to the limited time, this paper is still deficient in research. Therefore, there are some recommendations for future research to build upon this thesis. Firstly, different aspects of coal mining heritage can be studied in depth, such as the use of underground space for coal mining heritage, and the reuse of coal mining heritage far from the city as well as its relationship with urban regeneration. Besides, the transformation of China's mining cities can be studied in terms of public policy and economy. In addition, the study of the relationship between coal mining heritage and urban development in Jiaozuo city can also be explored in depth. The study of the preservation and reuse of Jiaozuo's industrial heritage can also be further studied at the level of architectural individual units. In-depth research can also be conducted on how to use the coal mining heritage to build the relationship between Jiaozuo and the surrounding cities.
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