

Investigation and Analysis of the Current Situation of Geothermal Resources Exploration and Exploitation in Yuncheng, Shanxi Province

Lijun Dong

Shanxi Geophysical and Chemical Exploration Institute Co., Ltd ,Yuncheng, 044004, Shanxi, China

Keywords: Yuncheng, Shanxi; Geothermal resources; Exploration and exploitation of resources; Environmental protection

Abstract: This article follows the principle of rigor in scientific research, aiming to investigate and analyze the current situation of geothermal resource exploration and exploitation in Yuncheng, Shanxi, and explore the current situation, existing problems, and solutions of geothermal resource exploration and exploitation. Specifically, the article aims to understand the distribution, reserves, and current exploration and exploitation status of geothermal resources in Yuncheng, Shanxi through methods such as literature review, field investigation, and data analysis. Moreover, in-depth exploration is conducted on the problems existing in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi, and targeted solutions and suggestions are proposed. There are many problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi, and effective measures need to be taken to solve them. The government should increase its support and investment in geothermal development, introduce advanced technology and management experience, strengthen environmental protection awareness and technical talent training, in order to improve the exploration and exploitation level of geothermal resources in Yuncheng, Shanxi, and achieve sustainable growth of geothermal resources. Through the investigation and analysis of the distribution, reserves, and current exploration and exploitation status of geothermal resources in Yuncheng, Shanxi, as well as the exploration of existing problems and the proposal of solutions, this article will provide beneficial ideas and methodological support for the sustainable growth of geothermal resources in Yuncheng, Shanxi.

1. Introduction

Geothermal resources are a clean and renewable energy source with broad application prospects. It is mainly distributed at the edge of tectonic plates, originating from the decay of molten magma and radioactive materials on Earth[1]. At present, the exploration and exploitation of geothermal resources have received widespread attention and attention, and governments at all levels and relevant departments have also taken a series of measures to strengthen the exploration, exploration and exploitation of geothermal resources and environmental protection work[2-3].

On a global scale, the exploration and exploitation of geothermal resources has become an important development direction in the energy field. Shanxi Yuncheng is located in the southwest of Shanxi Province, with geographical coordinates of $110^{\circ} 15' - 112^{\circ} 04' E$ and $34^{\circ} 35' - 35^{\circ} 49' N$. The geothermal resources in this area mainly come from groundwater heat and fault zone heat[4]. According to geological structure and underground hydrological characteristics, geothermal resources in Yuncheng, Shanxi are mainly distributed in the Zhongtiaoshan Fault Zone, Linyi Fault Zone, and Jiangxian Yuanqu Fault Zone[5]. These fault zones not only provide favorable conditions for the formation of geothermal water, but also enable geothermal water to have a higher temperature and salinity. Shanxi Yuncheng geothermal water has high quality and is suitable for various purposes, such as hot spring tourism, heating, agricultural irrigation, etc.[6].

As one of the regions with abundant geothermal resources in China, the exploration and exploitation of geothermal resources in Yuncheng, Shanxi is of great significance for promoting regional economic development, improving energy utilization efficiency, and promoting environmental protection. However, there are still some problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi, such as resource waste and

environmental pollution, which seriously restrict the sustainable growth of geothermal resources in Yuncheng, Shanxi[7]. Currently, the exploration and exploitation of geothermal resources have received widespread attention in scholars' research. However, the research on the exploration and exploitation of geothermal resources in Yuncheng, Shanxi is not yet in-depth enough. Therefore, this article aims to investigate and analyze the current situation of geothermal resource exploration and exploitation in Yuncheng, Shanxi, and explore the current situation, existing problems, and solutions of geothermal resource exploration and exploitation. It is hoped that this research will provide new data and support for the research in related fields.

2. General situation of geothermal resources in Yuncheng, Shanxi Province

2.1. Types and distribution of geothermal resources in Yuncheng, Shanxi

Shanxi Yuncheng is located in the southwest of Shanxi Province, with geographical coordinates of $110^{\circ} 15' - 112^{\circ} 04' E$ and $34^{\circ} 35' - 35^{\circ} 49' N$. The geothermal resources in this area mainly come from groundwater heat and fault zone heat. According to geological structure and underground hydrological characteristics, geothermal resources in Yuncheng, Shanxi are mainly distributed in the Zhongtiaoshan Fault Zone, Linyi Fault Zone, and Jiangxian Yuanqu Fault Zone[8]. These fault zones not only provide favorable conditions for the formation of geothermal water, but also enable geothermal water to have a higher temperature and salinity. Table 1 shows the distribution of geothermal resources in Shanxi.

Table 1 Distribution of geothermal resources in Shanxi

Area	Geothermal resource types	Distribution
Taiyuan-Jinzhong section	Medium to low temperature porous layered thermal storage, medium to low temperature fractured layered thermal storage, medium to low temperature karst layered thermal storage	Mainly distributed in the southern part of the Sanwei Dilei South Fault in the urban area of Taiyuan City and various counties in Jinzhong City.
Datong-Shuozhou section	Medium to low temperature porous layered thermal storage, medium to low temperature fractured layered thermal storage	Mainly distributed in the urban area of Datong and its southwest region. When one of the exploration holes was drilled to 1624.01 meters, high-temperature and high-pressure geothermal fluid was detected, with an orifice temperature of 160.2 °C and a single well flow rate of over 230 cubic meters/hour, making it the geothermal well with the highest temperature and maximum self flow rate discovered in the central and eastern regions of China.
Xinzhou area	Medium to low temperature fractured layered thermal storage and porous layered thermal storage	Mainly distributed in the basins of Dingxiang Xinzhou Yuanping Daixian Fanzhi area. Porous layered thermal reservoirs are mainly distributed in Qicun, Daying, and other places
Changzhi-Jincheng section	Medium to low temperature karst layered thermal storage	Mainly distributed in Qinyuan County, Qinxian County, Wuxiang County, Tunliu District, and parts of Changzi County in Changzhi City, as well as parts of Qinshui County and Yangcheng County in Jincheng City
Yuncheng area	Medium to low temperature porous layered thermal storage, fractured layered thermal storage, and karst layered thermal storage	Mainly distributed in Yuncheng, Linfen, and other places. The medium to low temperature porous layered thermal reservoirs are distributed south of the Linyi Fault Zone and in Ruicheng, Pinglu, and other areas of the Yuncheng Basin; Fractured layered thermal reservoirs are mainly distributed in the edge area of the Houma Basin north of the Linyi Fault Zone; Karst layered thermal reservoirs are distributed in the edge area of Yanchi in the Yuncheng Basin

2.2. Reserves and quality of geothermal resources in Yuncheng, Shanxi Province

According to relevant geological data and field investigations, the reserves of geothermal resources in Yuncheng, Shanxi are relatively abundant. Among them, the Zhongtiaoshan Fault Zone and Linyi Fault Zone are the main distribution areas of geothermal resources in Yuncheng, Shanxi, with geothermal water temperatures generally ranging from 40 °C to 65 °C and up to 90 °C[9]. In addition, the geothermal water temperature in the Jiangxian Yuanqu fault zone is relatively high, but its reserves are relatively small. Overall, the quality of Shanxi Yuncheng geothermal water is high and suitable for various purposes.

3. Problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi Province

(1) The level of exploration and exploitation is relatively low: Currently, the exploration and exploitation of geothermal resources in Yuncheng, Shanxi is still in its early stages, lacking a unified management mechanism and technical standards. The extraction and utilization of geothermal water mainly rely on traditional experience and technology, resulting in low utilization efficiency and serious waste of geothermal resources.

(2) Severe resource waste: Due to the lack of effective management and planning, some regions have overexploited geothermal resources in development, resulting in severe waste of geothermal resources. The mining output of some geothermal wells has exceeded the range of local geological conditions and groundwater resources, leading to the decline of groundwater level and depletion of geothermal wells.

(3) Environmental pollution issues are prominent: some regions lack environmental protection awareness during geothermal development, leading to problems such as geothermal water pollution and soil pollution. Geothermal water contains abundant chemical components, such as hydrogen sulfide, fluoride, etc. If these components are directly discharged without treatment, they can have serious impacts on the surrounding environment and human health.

(4) Weak technical strength: The exploration and exploitation of geothermal resources in Yuncheng, Shanxi requires professional technical talents and advanced equipment and instruments. However, at present, the technical strength of Shanxi Yuncheng in the field of geothermal development is relatively weak, lacking professional technical talents and equipment and instruments, making it difficult to meet the needs of large-scale and efficient geothermal development.

(5) Insufficient capital investment: The exploration and exploitation of geothermal resources require a large amount of capital investment. However, the current funding investment in the geothermal development field in Yuncheng, Shanxi is still insufficient, making it difficult to meet the needs of large-scale and efficient geothermal development. Moreover, due to a lack of financial support, some geothermal development projects are also difficult to effectively promote and implement.

4. Present situation of geothermal resources exploration and exploitation in Yuncheng, Shanxi Province

4.1. Current status of exploration and exploitation

The current situation of geothermal resource exploration and exploitation in Yuncheng, Shanxi shows a steady development trend. In recent years, with the increasing emphasis and support of the country for renewable energy, the exploration and exploitation of geothermal resources in Yuncheng, Shanxi has also been promoted and developed accordingly[10]. Firstly, the reserves and quality of geothermal resources in Yuncheng, Shanxi are quite abundant. According to relevant geological data and field investigations, the quality of geothermal water in Yuncheng, Shanxi is high and suitable for various purposes, such as hot spring tourism, heating, agricultural irrigation, etc. Secondly, the exploration and exploitation of geothermal resources in Yuncheng, Shanxi has

begun to take shape. Some regions have already built some geothermal heating projects and hot spring tourism facilities, such as the "Four Seasons Muge" hot spring resort in Yanhu District of Yuncheng City, Shanxi Province, and the Wulaofeng hot spring in Yongji City[11]. The completion and operation of these projects not only injected new vitality into the local economic development, but also increased the visibility and brand value of geothermal resources in Yuncheng, Shanxi. However, there are still some problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi. The most prominent issues among them are resource waste and environmental pollution. Moreover, due to the lack of effective management and planning, some areas have caused problems such as geothermal water pollution and soil pollution during the geothermal development process. The existence of these problems seriously restricts the sustainable growth of geothermal resources in Yuncheng, Shanxi.

4.2. Solution measures

In order to solve the problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi, relevant departments can take the following measures:

(1) We should strengthen the supervision and management of geothermal resources, establish a unified geothermal resources management system and technical standards, standardize the exploitation and utilization of geothermal water, and avoid over-exploitation and waste of resources.

(2) We should encourage the recycling and wastewater treatment of geothermal water, improve the utilization efficiency of geothermal water, reduce the impact on groundwater resources, and strengthen the monitoring and management of geothermal water discharge to avoid negative impact on the environment and human health.

(3) Introduce advanced technology and equipment: We should actively introduce advanced geothermal development technology and equipment at home and abroad. This will help to improve the level of development and utilization of geothermal resources, reduce the development cost and improve the overall development efficiency.

(4) Strengthen the training of technical personnel: We need to pay attention to the training of technical personnel in the field of geothermal resources development. Our goal is to build a high-quality geothermal development team and further improve the level of geothermal resources development and utilization.

(5) Carry out geothermal resources planning: We need to carry out comprehensive geothermal resources planning. Considering the local geological conditions and groundwater resources, we have made a wise plan for the development and utilization of geothermal resources. This ensures responsible development practices, prevents over-exploitation and minimizes waste of resources.

(6) Implement incentive mechanism: We need to formulate incentive mechanism for the exploration and development of geothermal resources, encourage enterprises to increase investment and development of geothermal resources, and promote the development of geothermal industry.

(7) Strengthen the popular science education of geothermal resources: We should also strengthen the popular science education of geothermal resources, raise the public's awareness of geothermal resources and protection, and promote the sustainable utilization of geothermal resources.

(8) Strengthen the exploration of geothermal resources: We can further understand the distribution and reserves of local geothermal resources by strengthening the exploration of geothermal resources, and provide more accurate geological data for the exploration and development of geothermal resources.

(9) Strengthening environmental protection: practitioners should strengthen environmental protection in the process of geothermal development to avoid negative impact on the environment and human health. For example, strengthen the monitoring and management of geothermal water pollution and soil pollution to reduce the impact on the surrounding environment.

(10) Strengthen international cooperation: We need to strengthen cooperation with the international community in the field of geothermal resources exploration and development, introduce advanced foreign geothermal development technology and experience, and improve the

level of geothermal resources exploration and development in China.

5. Prospect of geothermal resources exploration and exploitation

Geothermal resources are a valuable comprehensive mineral resource, and they are also a clean and renewable energy source. It can be used in various fields such as heating, hot spring tourism, agricultural irrigation, and has broad application prospects and important economic, social, and environmental benefits. Strengthening the exploration and growth of geothermal resources is of great significance for promoting regional economic development, improving environmental quality, and ensuring national energy security. Table 2 shows the distribution of geothermal resources in China.

Table 2 Distribution of geothermal resources in China

Region	Distribution of geothermal resources
Xizang	Xizang is rich in geothermal resources, mainly concentrated in the Himalayas
Yunnan	Yunnan is rich in geothermal resources, mainly concentrated in Tengchong, Yuanmou, and other places
Shanxi	Shanxi is rich in geothermal resources, mainly concentrated in areas such as Taiyuan Jinzhong area, Datong Shuozhou area, Xinzhou area, Changzhi Jincheng area, etc
Fujian	Fujian is rich in geothermal resources, mainly concentrated in the southwestern region of Fujian
Jiangxi	Jiangxi is rich in geothermal resources, mainly concentrated in Yichun, Pingxiang, and other places
Xinjiang	Xinjiang is rich in geothermal resources, mainly concentrated in mountainous areas such as the Tianshan and Kunlun Mountains
Liaoning	Liaoning is rich in geothermal resources, mainly concentrated in areas such as the Liaodong Peninsula and Dalian

With the continuous progress and application of science and technology, the exploration and exploitation of geothermal resources will further expand their application scope, such as geothermal power generation and geothermal refrigeration. This will provide broader development prospects for the exploration and exploitation of geothermal resources in Yuncheng, Shanxi. The exploration and exploitation of geothermal resources have advantages such as energy conservation, pollution reduction, and environmental protection, while also bringing good economic and social benefits to the local economic development. For example, geothermal heating can replace traditional coal heating, reducing environmental pollution and energy consumption; Hot spring tourism can attract more tourists and promote the growth of local tourism industry.

6. Conclusions

At present, there are still some problems in the exploration and exploitation of geothermal resources in Yuncheng, Shanxi. Firstly, the level of exploration and exploitation is relatively low. At present, the exploration and exploitation of geothermal resources in Yuncheng, Shanxi is still in its early stages, lacking a unified management mechanism and technical standards. Secondly, there is a serious waste of resources. Some regions lack effective management and planning in geothermal development, resulting in excessive exploitation and serious waste of geothermal resources. Finally, the issue of environmental pollution is prominent. Some regions lack environmental protection awareness during geothermal development, leading to problems such as geothermal water pollution and soil pollution. In order to address these issues, relevant departments have taken a series of measures. Firstly, the management and planning of geothermal resources have been strengthened, and a unified geothermal resource management system and technical standards have been established. Secondly, the recycling and wastewater treatment of geothermal water have been strengthened, improving the efficiency of geothermal water utilization and

environmental protection awareness. Moreover, efforts have been strengthened in technology introduction and talent cultivation, improving the exploration and exploitation level of geothermal resources in Yuncheng, Shanxi.

Overall, the current situation of geothermal resource exploration and exploitation in Yuncheng, Shanxi shows a steady development trend. Although there are still some problems that need to be solved, with the increasing emphasis and support of the country for renewable energy, as well as the strengthening of management and planning work by relevant departments, technology introduction, etc., it will further inject new vitality into the local economic development and improve the quality of life of local residents. The research in this article will help to gain a deeper understanding of the current exploration and exploitation status of geothermal resources in Yuncheng, Shanxi, and provide reference for relevant departments to formulate policies. Meanwhile, exploring the existing problems and solutions will help improve the utilization efficiency and environmental protection level of geothermal resources in Yuncheng, Shanxi, and achieve sustainable growth of geothermal resources.

References

- [1] Zhang Mohan, Chen Muxian, Zhang Chenlin. Geothermal resources exploration and exploitation and strategic layout [J]. Chinese Sci-tech Journal Database (Citation Edition) Engineering Technology, 2020(11):2.
- [2] Wang Xin, Xiong Yingxing. Analysis of major environmental problems in the exploration and exploitation of geothermal resources [J]. Chinese Sci-tech Journal Database (Abstract Edition) Engineering Technology, 2021(9):2.
- [3] Guo Yuping. Geothermal resources exploration and exploitation of environmental problems and protective measures [J]. Metallurgical Management, 2019(23):2.
- [4] Chang Zhongchang. On the existence of hot and dry rock geothermal resources in Yuncheng Basin [J]. Natural Resources in North China, 2019(4):2.
- [5] Xue Yuze. Analysis of major environmental problems in the exploration and exploitation of geothermal resources [J]. Northern Environment, 2018, 30(5):206-206.
- [6] Lin Qiang. Genetic analysis of geothermal resources in wenxi county, Shanxi [J]. Western Exploration Project, 2021, 33(11):3.
- [7] Qiu Dalu, Lv Sixue. Study on the causes of geothermal resources in Jimo Hot Springs and the countermeasures for their development, utilization and protection [J]. Groundwater, 2023, 45(3):13-16.
- [8] Ran Yujin, Zhang Hao. Investigation and growth of shallow geothermal energy resources [J]. Heilongjiang Metallurgy, 2018, 038(005):1-2.
- [9] Chen Yan. Chemical and Isotopic Characteristics of Geothermal Fluid in Beichi Area of Xinjiang County, Yuncheng City [J]. Natural Resources of North China, 2023(3):60-62.
- [10] Yu Jing, Ouyang Xiang. Analysis of major environmental problems in the exploration and exploitation of geothermal resources [J]. Comprehensive utilization of resources in China, 2020, 38(4):3.
- [11] Wang Zheng. Geothermal resources exploration, exploration and exploitation and protection countermeasures [J]. Ecological environment and protection, 2019, 2(3):2.