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Underground Space Conception Based on Abandoned Mine

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Abstract: Based on the massive underground space resources, and with the deep development of the policy to cut overcapacity in the coal industry, a large number of abandoned mines will appear sometime in the future. How to use abandoned mines rationally, and how to maximum their effectiveness. According to the spatial characteristics of the discrete distribution of abandoned mines in China and their cluster distribution of regional characteristics, an overall planning area for all abandoned mines is put forward, and according to their characteristics, they are divided into three categories: “command mine”, “transfer mine” and “functional mine”. "Command mine", as the "central nerve" of the mine group in the region, connects with each "transfer mine" and gives unified instructions. "Transfer mine" is the transfer station of information. After receiving the instructions issued by "command mine", it will quickly process and package the information, and then reach each “functional mine” under classification, which serves as a link between the preceding and the following. And the "functional mine" can be used as a place for material reserves or personnel activities according to the specific “mission” borne by its characteristics. This concept plans all the abandoned mines in the area, and these abandoned mines will be built into an underground space of continuation. Thus, the single development mode that the existing mine cannot cluster planning is abandoned.

1. Introduction

"Lack of gas", "less oil" and "relatively rich coal" are the current energy characteristics of China [1]. With the "11th Five-Year Plan", "12th Five-Year Plan", "13th Five-Year Plan" and other meetings, China will close a large number of mines. According to statistics, by 2030, the number of abandoned mines in China will reach 15,000 [2]. Some of these abandoned mines contain a large amount of coal bed methane, geothermal energy and huge underground space. According to statistics, the coal reserves in China's abandoned mines are as high as 42 billion tons, nearly 500 billion cubic meters of natural gas, and nearly 7.2 billion cubic meters of underground space [3-4], which shows that China's abandoned mines are rich in resources and have huge development potential [5].

In order to avoid the waste of resources in abandoned mines, Chinese scholars have made corresponding studies: Zhu Chaobin et al analyzed the underground spatial structure of abandoned mines based on space syntax theory [6]. Puhai et al. used analytical model and numerical calculation to evaluate the feasibility of geothermal resource utilization in abandoned mines [7]. Domestic

scholars estimate gas resources in abandoned mines by establishing coal-bed methane prediction models [8]. Some established CBM resource evaluation methods and models of abandoned mines through theoretical analysis and mathematical derivation to evaluate CBM resources in gob areas [9]. Hao Xianjie et al. put forward the index of underground space storage and the transformation technology [10].

On the whole, China started late in the field of abandoned mine recycling. There are few scientific planning and design of existing abandoned mines, and few cases of accurate development. It is far less perfect than the theoretical system and mature technology of European and American countries [11-12]. And the transformation mode is single. The main mode at this stage is to visit the park, such as Jiangsu Xiangshan National Mine Geopark [13], Shanghai Chenshan Botanical Garden Mine Garden [14], Hubei Huangshi National Mine Geopark [15] and so on. The number of abandoned mines in China is large and has discrete characteristics. If an abandoned mine is developed separately, it will inevitably cause waste of resources in other abandoned mines with small development value. Therefore, the author puts forward a conception that all abandoned mines in a certain area are summarized and counted according to the type, size and quantity of mines, and unified planning. According to the characteristics of different abandoned mines, different functions are given to them, and they are transformed into mines with a certain ability. These abandoned mines are connected and radiated from a central mine to the periphery to form a multi-functional underground space network. This concept takes the abandoned mine of coal mine as the main body, combined with some other kinds of mines, in order to achieve the use of large and small abandoned mines, and improve the utilization rate of abandoned mines in China. The distribution of abandoned coal mines in China is shown in figure 1.

Figure 1: The distribution of underground space can be effectively utilized by coal mine waste in all provinces of China

2. Design scheme

First of all, it is necessary to find a large abandoned mine in an area as the “command mine” of the scheme, radiate to the surrounding area with the “command mine” as the center, select a larger abandoned mine as the “transit mine”, and then radiate to the surrounding area with each “transit mine” as the center, establish multiple “functional mines”, and connect the “command mine” with the “transit mine” through a certain connection method, and connect the “transit mine” with the “functional mine”, so as to realize the unified planning and integration of a large number of various

types of abandoned mines in the area. “Functional mine” is an abandoned mine that plays a specific function in the scheme. It belongs to the third-level mine in the scheme. Its functions can include: oil storage, natural gas storage, grain storage, water resources storage, underground living material storage, and temporary storage of ammunition and other military materials in wartime. At the same time, it can expand the capacity of “functional mine”, not only limited to the storage of materials, but also can be built into underground hospitals, underground farms and other places. These places can operate independently in peacetime, and part of the income is used for daily maintenance of the mine to ensure the basic safety of the mine and personnel.

The “transit mine” is used to connect the “command mine” and the “functional mine” in the scheme, which belongs to the secondary mine in the scheme. The name of “transit mine” is determined according to the specific materials stored in each “functional mine” connected with it. If it is connected with “oil storage functional mine” and “gas storage functional mine”, it is called “energy transit mine”. If it is connected with “grain storage function mine”, “water storage function mine” and “living material reserve mine”, it is called “living material transit mine”; if it is connected with the “underground agricultural field”, it is called a “sustainable transit mine”; if it is connected with “underground hospital” and “medical waste disposal mine”, it is called “medical transit mine”. In this form, the “transit mine” is subdivided, and the specific functions of the underground network in a small area are given, with professional counterpart construction design, circuit design and so on. The underground network of small area is composed of two parts: “function mine” and “transit mine”. Regional large-scale underground network refers to the underground space in the area covered by the whole design scheme.

The “command mine” is the command center of the scheme and belongs to the first-level mine. It is connected with each “transit mine”, through the “transit mine” to realize the connection between the underground network of each small area and the “command mine”, so as to form a large underground network in the area, and the “command mine” is the “central nervous system” of the scheme. The design scheme is shown in Figure 2.

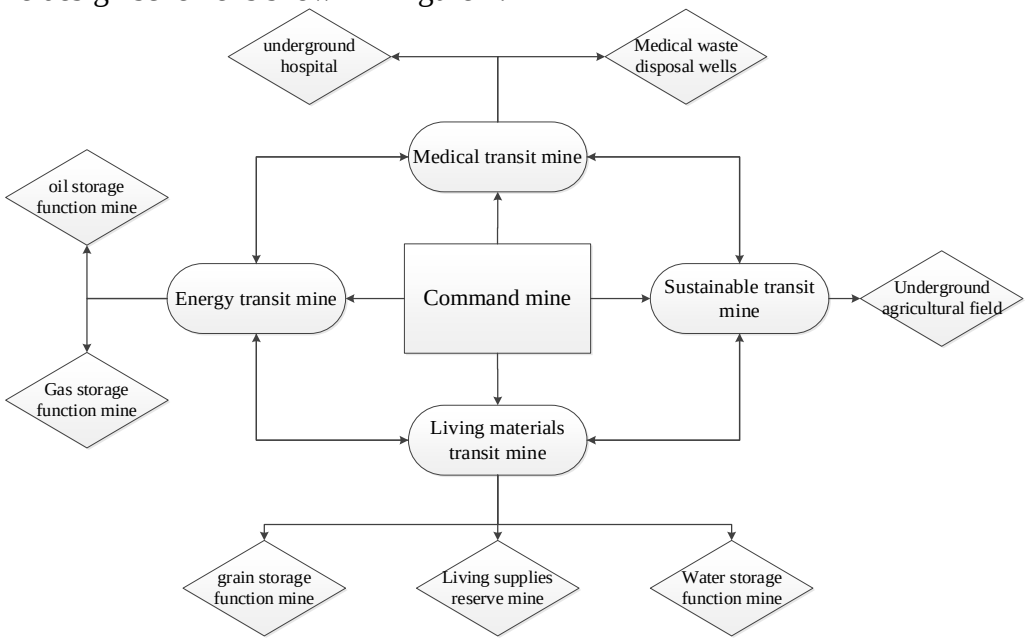

Figure 2: Schematic design drawing

3. Introduction of all levels of mines

3.1 Function mine

As the name implies, “functional mine” is an abandoned mine that performs a specific function. It can carry out oil, gas, food, water and other resources storage; it can also be used as a temporary placement well for medical waste; it can also play the functions of hospitals and farms. The author thinks that we can choose what kind of materials to store according to the particularity of different kinds of mines.

The 'oil storage function mine' can choose the abandoned mine of coal mine, but at the same time the following conditions should be met: First, the selected abandoned mine should have stable rock mass conditions and stable roof conditions. Second, the site should have a stable groundwater level [16]. If the selected abandoned mine roof and surrounding rock are easy to damage and change, it will face the timeliness problem of oil storage. If the groundwater level at the site is unstable, the water seal pressure condition of the oil storage tank cannot be guaranteed, which is easy to cause oil leakage and volatilization, and more likely to cause land pollution. Underground oil storage also faces the problem of spatial structure of abandoned mines. The reserve capacity of combat readiness oil storage is often huge, so a large number of abandoned mines are needed, and the space in abandoned mines is required to be large. The roadways and chambers in abandoned mines will prefer the stable position of rock strata when they are built. The supporting conditions are good, and the space occupied is also large, so they can be used as specific oil storage areas.

The “grain storage function mine” can choose the abandoned limestone mine. Because grain storage involves factors such as temperature and humidity, the selected abandoned mine should have good low temperature effect and good moisture control effect [17]. The temperature of the abandoned limestone mine is kept at more than ten degrees all the year round, and the most suitable temperature for grain storage is 15 ℃ to 20 ℃, and limestone can absorb the moisture of the air in the mine to a certain extent, and also achieve the effect of humidity control. The grain storage base is large, so the best mine selected should be universal. China is one of the countries with abundant limestone resources in the world, basically throughout the country. Compared with other abandoned mines, abandoned limestone mines are more suitable as “grain storage function mines” in terms of storage effect and mine base. For example, the United States has transformed the abandoned limestone mines in Kansas City into underground grain depots [18]. Underground salt caverns provide an ideal space for large-scale storage of natural gas [19-21].

The “underground hospital” is a place that needs to be built in the plan. Because the construction site is underground, it is not exposed to sunlight all year round, and it is in a humid environment and is easy to breed microorganisms such as bacteria and fungi. Therefore, in the process of building underground hospitals, special attention should be paid to shockproof, waterproof and anti-microbial. We can learn from an underground hospital in Bonn, Germany. The hospital has operating rooms, disinfection rooms, wards, baby rooms and other professional medical functional rooms, as well as drinking water treatment stations, sewage pumping stations, air purification rooms, refrigeration equipment rooms, power rooms, material warehouses and other functional rooms. It is these different functional rooms that operate together to maintain the normal work of the underground hospital. The construction of underground hospitals is to deal with emergencies to a certain extent, so the author believes that it should also be given the function of national defense education for all entrants. In peacetime, underground hospitals can alleviate the pressure of urban medical treatment to a certain extent; the underground hospital can be well covered during the war preparedness period, so as to protect the lives of the injured. The functional structure of the underground hospital is shown in Figure 3.

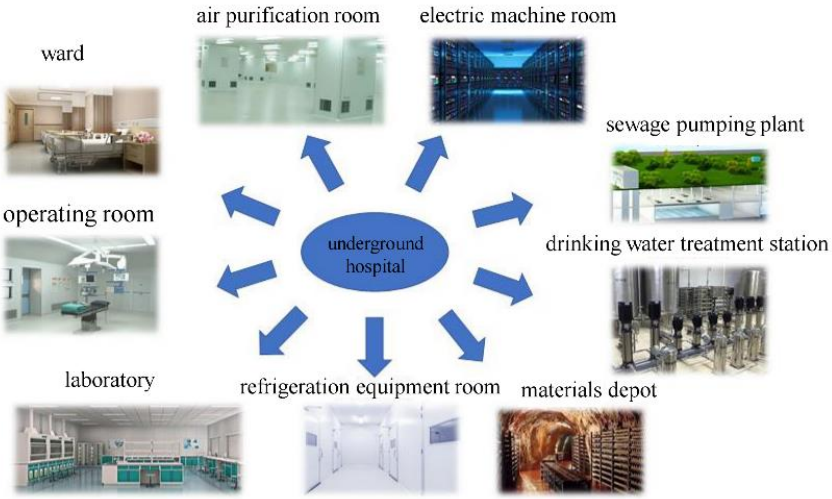

Figure 3: Functional structure diagram of underground hospital

"Underground agricultural field" can plant vegetables in large quantities. Due to the deep underground space, the growth cycle of vegetables is short. Different vegetables can be harvested in only 6 to 28 days. Before the fresh vegetables are sent to the ground city, a new round of planting can be started. These vegetables will be used for daily consumption in the city. In special periods, underground agriculture can provide necessary vegetables and other foods for people underground, which is an active strategic reserve. The underground farm is shown in Figure 4 [22].

Figure 4: Underground farm

3.2. Transit mine

The "transit mine" is not a mine for storing materials. Its functional positioning is information receiving and sending, traffic transit, transportation scheduling, and opening and closing of underground networks in small areas. According to the division of "functional mine", the "transit mine" in the scheme is divided into four categories: energy transit mine, living material transit mine, sustainable transit mine and medical transit mine. The "transit mine" is a secondary mine, which plays a connecting role. It receives information from the "command mine". If the information involves the operation of the "functional mine", the information is transmitted to the "functional mine". Each "functional mine" should be connected with the corresponding "transit mine" to form a small area underground network, but these small area underground networks still belong to discrete forms. In order to connect several small area underground networks, it is necessary to connect the two adjacent "transit mines" through the "transit mine", and each "transit mine" should be connected with the "command mine", so as to realize the connection of abandoned mines in the whole large area. When oil, natural gas, food, water and other resources need to be transported, the information interaction

between the “transit mine” at the upper level of the “functional mine” and the “transit mine” on the transportation route should be carried out to achieve accurate scheduling and safe transportation. The last function of the transit mine is to open and close the underground network of a small area. The principle is that the “transit mine” has the function of connecting the “functional mine” and the “command mine”. The interconnection of “transit mines” connects the underground network of small areas together, so the closure of a transit mine will disconnect the traffic of the small area mine group from the traffic of the whole mine group. It can also disconnect the traffic of a “transit mine” from the traffic of its subordinate “functional mine”. If the underground system is penetrated by foreign personnel, the purpose of preserving the whole underground system can be achieved by closing the penetrated “transit mine”.

3.3 Command mine

The “command mine” is the first-level mine of the scheme, and its functional positioning is to receive and send information, real-time monitoring, dispatching transportation, and general control subsystems. It can send instructions to “transit mine”, and can also receive feedback information from “transit mine”, so as to achieve real-time monitoring of “functional mine” and “transit mine”. It can also carry out the scheduling of oil, natural gas, grain, water and other reserve resources. First, the scheduling route is planned, then the command is issued to the “transit mine”, and finally the transportation is started. The “command mine” is the “central nervous system” of the scheme, because it is responsible for controlling the subsystems of the regional underground network and is the total control of all subsystems. In a special period, the “command mine” can be immediately transformed into a military command center. Because it is deep underground, it can effectively avoid multiple attacks from the enemy and ensure that we can effectively fight back after being attacked. The “command mine” is the shell of the command and control system. Its construction will be related to the outcome of a war and determine the safety of a country. Therefore, the construction of the command mine is the top priority.

As an underground command mine, it also has its outstanding characteristics: First, we should pay attention to the comprehensive killing effect of weapons. Second, pay attention to improving the overall viability and overall effectiveness of the protection system. Third, emphasize long-term planning, rolling development, and gradually build a complete modern underground protection system [23]. In terms of its function, it can learn from the United States Xiayan Mountain Command Center.

The construction of “command mine” in the scheme should meet three conditions: First, the nature of the surrounding rock of the abandoned mine is stable, the roof is stable, and the groundwater level is stable. Second, the underground space of abandoned mines should be large. Third, choose the abandoned mine built along the mountain, so that the whole mountain can be used as a shelter for the underground command center. There are a large number of roadways, shafts and chambers in large abandoned mines. A part of them can be selected for the reserve of daily living materials to ensure that the personnel in the bunker during the special period can be adequately supplied. The modern underground protection engineering system is a costly, complex and long-term project, so it needs to invest a lot of manpower, material and financial resources.

4. Connection method

Because the purpose of this scheme is to connect the abandoned mines in the area to form an abandoned mine network group, it may encounter the situation that the distance between the “transit mine” and the “transit mine” is far, or the problem that the distance between the “transit mine” and the “command mine” is far. At this time, it is necessary to build traffic lines to connect these discrete

abandoned mines, so that they are no longer independent, but become a connected body.

Therefore, the author believes that there are two options for the design of the traffic line in the scheme. First, long-distance underground track connection. Second, the combination of surface roads and underground roads. If the “long-distance underground track connection” method is selected, the advantage is that the single-trip transportation volume is large and the transportation speed is fast; however, the disadvantage is that the construction of too long underground tunnels will increase the amount of engineering, followed by too long underground tunnels cannot guarantee the flow of air, and too long underground tunnels will increase the workload of maintenance personnel and their safety problems cannot be fully guaranteed. If the combination of surface highway and underground highway is selected, it can be transformed on the basis of the original abandoned mine, and some shallow roadways can be transformed into highways, which will not increase too much engineering quantity. A section of underground highway, a section of surface highway, this way can avoid the construction of too long underground tunnel; the disadvantage is that a single car transport is far less than the rail transport, and the speed is not fast. The author prefers the second connection method, because the small amount of work and the safety of personnel can be guaranteed.

5. Conclusion

(1) The mines used in underground space are divided into first-level “command mine”, second-level “transit mine” and third-level “functional mine”. The “command mine” is the brain of the whole underground space, which is responsible for the overall command and dispatch, and plays the role of military command in wartime. “Transfer mine” undertakes the responsibility of information receiving and sending, traffic transfer, transportation scheduling and opening and closing of underground network in small area. “Functional mine” is responsible for specific material reserves and play a certain function.

(2) Through the ' underground road and surface road ' or ' long-distance underground track connection ', each abandoned mine is connected, and the abandoned mine in this area is turned into a whole to form a continuous multi-functional underground space.

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