The Karst Water in Han-Xing District and the Countermeasure in Water Management

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ABSTRACT

The karst water system in Han-Xing District is charaterised by heterogeneity in karstification and permeability of the limestone aquifer, unsteady flowing of the groundwater along karst runoff zone system, periodic recharge related with the periodic precipitation, and concentrative discharge of the groundwater in the form of karstic spring groups. The basic law is that the quantity of the water is very large during waterflood period and rather small in dry period, which has brought about difficulties and contradictions in mining and water supply. The measure to bring the karst water under control must be based on the principle of comprehensive ways and on the systems engineering method. Macroscopicly, it is the reasonable countermeasure to retain surface water in the upstream section of the karst water system and to strengthen infiltration in the midstream section and to combine exploitation and utilization of the groundwater with water protection and mine dewatering in the area in which mines are distributed.

INTRODUCTION

The Han-Xing District is rich in coal and iron mineral resources, but most iron deposits and the lower coal seams haven't been exploited as yet because of the impacts of the Cambrian and Ordovician karst water. The karst water plays an important part in the industry, agriculture and the urban water supply despite of being the hazard to mining. Should the coal, iron and water resources be synthetically developed and utilized, the comprehensive regulation of karst water is the only way.

From the systems engineering point of view, this paper clarifies the karst water characteristics and the relations between the inner properties of karst water

system and the outer environment and approached the macroscopic tactics of the karst water regulation.

OUTLINE OF HYDROGEOLOGY

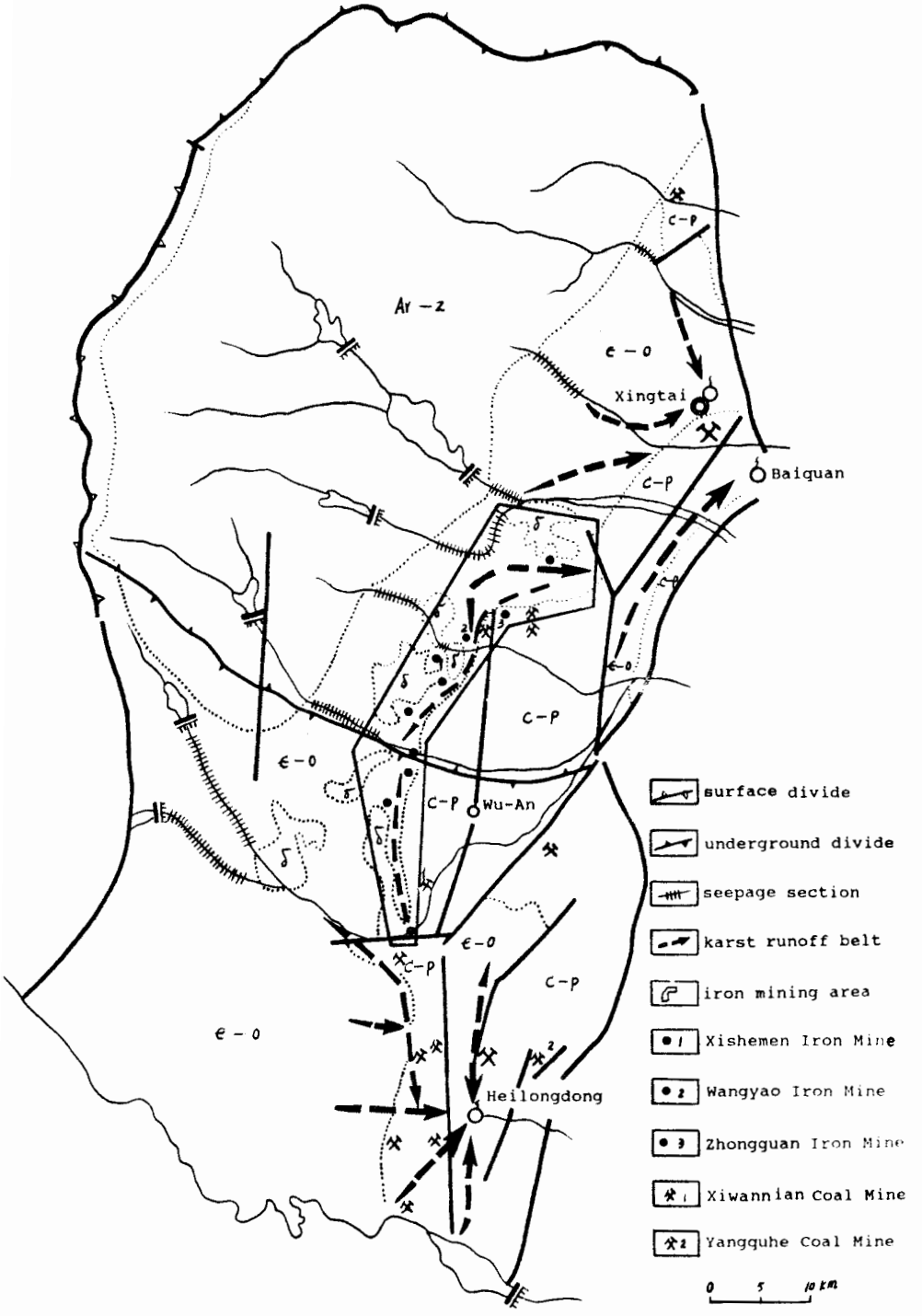
East of the Taihang mountains is the Han-Xing District in the south of Hebei Province, with hillyland in the west and the plain in the east. It is the area of the continental semi-arid climate. The rainfall is 500~600mm per year, of which the minimum is less than 300mm and the maximum up to 1,400mm . 80 percent of the precipitation in a year is concentrated in July to September and there is a flood year with the precipitation of more than 800mm in every seven to eleven years.

Nine rivers over the district are all intermittent with the exception of the two perennial --- the Zhanghe river and the Fuyang river. The seepage occurs in the outcrop area of limestone along the rivers.

In the district a number of outcrops can be found of the Precambrian and the Cambrian, the Ordovician, the Carboniferous, the Permian, the Tertiary and the Quaternary. The main aquifer is the water-bearing karstified limestone of the Ordovician System. The coal beds are in the Carboniferous-Permian System , the iron deposits in the Ordovician System.

The Han-Xing District is a transitional zone between the uplifted area and subsiding area. The dip of the strata showing macroscopically a monocline and trending NNE is 10~25 degrees SEE. Faults well developed are mostly the high-angle normal faults and some gentle folds are developed somewhere. A chain of terraced grabens and horsts were formed in the coal mining area. The structural lineament is just corresponding to the strike of strata. The igneous rocks is mainly the dioritoid of the Yanshan Period in the form of column or complicated stratoid.

The karst water in accordance with the spring catchment can be divided into two systems: the Baiquan spring system and the Heilongdong spring system. Bounded by the surface watershed at the boundary of Hebei Province and Shanxi Province in the west, the Xingtai fault in the east, the Beiminghe underground divide and Neiqiu underground divide respectively in the south and north, the catchment area of the Baiquan system is about 800 square kilometers with the outcrop of limestone of 350 square kilometers. The Heilongdong catchment is about 2400 square kilometers with the boundaries of the Shexian fault in the west, the Gushan hill in the east, the Beiminghe underground divide in the north and the divide along Zhanghe river in the south. The outcrop of limestone is about 1200 square kilometers.



Hydrogeological sketch of the Han-Xing District

The hydrogeological characteristics of the two systems are similar in inner structure and interaction between the system and the outer environment.

1> Karst water-storing conditions
The water-bearing medium is mainly the Cambrian and Ordovician karstified carbonatite. The karst form is mainly karst fissures, caves and holes.The karst aquifer is charactised by multi-layers, inhomogeneity and systematicness with the effects of the lithology, tectonic disturbances and hydrodynamics.

The network system consists of the fissures and karst fissures, caves and holes, which forms a water-storage reservoir. The void spaces are inhomogeneously distributed---the strong runoff belt which has been highly karstified rich in water is obviously distributed along the structural belt; the weak runoff zone performing the storage function is formed by the network of fissures and karst fissures with poor development. The underground reservoirs in the two systems are vast enough to hold great amount of water which can regulate the water reserves. It is estimated that the static water is about 2.2 billion cubic meters in the Baiquan and 2.4 billion cubic meters in the Heilongdong systems.

2> Hydrodynamics of karst water
The karst runoff zone system consists of the strong runoff belts and the weak runoff zone in the spring catchment. The sequence of the unstable groundwater movement is that groundwater in the weak zone firstly flows to the strong runoff belt nearby and then it is transferred to the outflow region. The flow is mainly laminar in uniform flow field where it presents that the strong runoff belt with a relatively low water level has a flat gradient such as the longitudinal gradient in the runoff belt of the Baiquan system ranging from 0.01~0.5 % and 0.02~0.4 % in the Heilongdong system. In the weak runoff zone, the longitudinal gradient becomes much more steep, generally from 0.75~2.0 % . In the discharge areas and the places where two or more runoff belts converge, the gradient is the minmum. The phreatic aquifer covers most region other than the coal-bearing strata with the confined aquifer.

3> Recharge of karst water
Precipitation is the recharge source of the two groundwa ter systems. The concentration recharge periodically to the karst water systems depends upon the periodicity and concentration of rainfall. An important part is played in the balance of groundwater by the high-water year in the cycles of 7~11 years.

The recharge to the two systems is quite different in

form. In the Baiquan system, it is derived mainly from the leakage of the rivers where the average seepage loss is about 6 cubic meters per second, over 60% of the total recharge to it. The recharge of the Heilongdong system is mainly from the infiltration of precipitation through the outcrop area of limestone. The average infiltration is about 11 cubic metres per second, over 80% of the total recharge.

4> Discharge of karst water
The natural discharge is only the karst spring complex in the two karst systems. The discharge is ranging from 6~9 cubic meters per second, the maximum is 38.5 cubic meters per second and the average flow rate of several years is about 10 cubic meters per second in the Heilongdong system. The Baiquan system has a flow rate of 4~6 cubic meters per second, the maximum 11 cubic meters per second and the average is about 7 cubic meters per second. In the last few years, the flow rate has been reduced and te springs have become exhausted recently because of the reduction of the rainfall and the increase of groundwater extraction. With the exception of the natural discharge, the extraction is up to 2.5 cubic meters per second in the Baiquan system and 3.3 cubic meters per second in the Heilongdong system.

The comparison with the pore-water system in North China indicates that the discharge is relatively unstable in karst water system with the fluctuation coefficient of 1.5~3 , the maximum is up to 5~20 in a year.

5> Regime of karst water
The karst water level varies much in time and space by the periodical recharge. A year is a small cycle of the fluctuation of groundwater level and a term of 7 to 11 years is a big one in which groundwater level would be greatly recovered in the wet year. The variation of water level is different in different regions. The water level is relatively stable both in the outflow region and the runoff belt but it varies great deal in the recharge region. The yearly fluctuation of the water level is about 1~3m in the discharge region of the Baiquan system, 1~4m in the Heilongdong system; 3~10m is in the runoff belts of the Baiquan system, 4~12m in that of the Heilongdong system; In the recharge region, 10~90m is in the former and 12~124m in the later.

Such is the characteristics of the karst water systems , which indicates the big difference of the hydrogeological conditions in the two water periods. The recharge to groundwater increases rapidly during the flood period, causing the water level of the recharge region to rise (about 100m) and the thickness and the transmissibility of the aquifer to increase as well. Meanwhile the discharge increases to a maximum as the gradient becomes more steep.

On the contrary, the water level drops down resulting from the lack of the recharge to the groundwater during the dry years of the big circle and the discharge are from the static water in the system. The transmissibilty of the aquifer becomes smaller, the gradient flater, the discharge reduces to a minimum. All mentioned above are the essential elements of karst water systems in the district.

THE REGULATION OF KARST WATER

The overall scientific regulation of the karst water in the district covering the factors of nature, society, economy, technology and environment etc. is a complicated systems engineering to study thoroughly in the future. The macroscopic countermeasure is only involved in this paper. According to the basic characteristics of karst water in the district, the macroscopic tactics must be based on synthetic regulation of surface and underground water. The main points are damming surface water at the upper reaches, intensifying infiltration at the middle reaches and uniting water control and utilization in the mining area.

1> Damming surface water at the upper reaches
The karst water system obtains some recharge from the Precambrian strata widely distributed in the western Han-Xing District, where groundwater occurs in the shallow bedrock fissures. During the rainy period, the rainfall is discharged by the river which obtains water from the fissures during the dry season so that the upper reaches are perennial. A dam built across the river to retain surface water may be so available that surface water may be considerably controlled and used .

2> Intensifying infiltration at the middle reaches
It is the recharge region of the karst water system where the precipitation and rivers, penetrating through the outcrop of limestone and the karst valley, infiltrate into aquifers. Obviously, it is unsuitable to adopt the means of preventing seepage and leakage in such an area. On one hand, leakage from the bottom of the rivers and its banks can not easily be packed; on the other hand, the means will let water flow off and reduce the recharge to the karst water system (especially to the Baiquan system). The trouble will increase with the reduction of the water resources. It is, therefore, in this region that the way of preventing seepage and leakage should not be taken but the intensifying infiltration in order to reserve the water from the upper reaches during the flood period to the underground reservoirs. In this way can the water resources increase in the system, moreover, the shortage of water on the surface during the dry period, due to the inhomogeneity of recharge, can obtain the compensation from the underground reservoirs where the water is used to

improve the capability of water supply.

3> Control-utilization of karst water in the mining area
The coal and iron mines in the mining area are located in the runoff region at the lower reaches and outflow region. The karst water regulation is comparatively complicated in the mines. Generally, the integration of the available control and rational utilization, of the drainage and supply should be taken to project water supply and drainage engineerings which is the help to control mine water on one hand, and to use the mine water as water supply source on the other hand.

The hydrogeolgical conditions of the iron mining area are quite different from that of the coal mining area so that the regulation tactics is accordingly different.

The iron mining area: Dewatering of the Ordovician limestone water is the best way depending on the occurrence and boundary conditions of the iron mining area and its inner structures. The iron mining area is located in the runoff belt of the two karst water systems and close to recharge region, far from the two spring complexes. It is surrounded by the impervious igneous rocks and water-resistant faults with only three openings of limestone whose permeability is weak (k= 0.4~2.12m/d) . The openings are connected with the regions of the intake and outflow. Therefore, the whole mining area is actually an independent secondary reservoir separated from the system, which is cut into several small reservoirs with relatively impervious boundaries by the inner structures and the igneous rocks. A number of deposits occur in the small reservoirs and some are in the bigger one. The particular bcundary conditions and inner structures of the iron mining area make it possible to dewater the karst water in the reservoir and dewatering will not damage the entire karst water system.

The regulation tactics can proceed orderly according to the particular conditions of the iron mining area:

<1> The direct dewatering can be carried out in the deposits respectively located in a small reservoir with well-closed boundaries. For example, the iron deposits south of Beiminghe river and the Xishemen Iron Mine.

<2> The deposits coexisted in a same reservoir with poor-closed boundaries can proceed with the unite dewatering. For example, the Zhongguan and Wangyao mines are within such a reservoir. Drawdown of several hundred meters by dewatering is very difficult for a single mine to undertake because of the large amount of static water of the reservoir and the large inflow from the vicinity. The primary principle to the deposits of this kind is the integrative dewatering , the combination of drainage and

water supply, deep-pumping on the surface and the drainage gallery and development of iron coal and water simultaneously.

The coal mining area: The coal mines obtain recharge indirectly from the Ordovician limstone aquifer. The way of deep drawdown by intensifying drainage cannot be used in all the mines . Generally, there is an impermeable bed with the thickness of 20~45m between the Ordovician limestone and the lower seams in the coal mining area. The backing water pressure of 100~150 kpa and the complicated structures are the potential danger to the exploitation of the lowest three seams. Owing to the different locations of the deposits, inrush of karst water to the mines will vary in the water amount. The rule of water control should be taken according to the practical conditions.

<1> the effective management of the water in the iron mining area can relieve the threatening to the coal mines either in the iron mining area or at the edge of it.

<2> In the weak runoff region, dewatering or withdrawing water pressure can be used in the coal mines with closed boundaries such as Yangquhe Coal Mine and the mines in the north part of Xingtai mining area and the eastern mines in the Wu-An mining area .

<3> The coal mines in the strong runoff belt and outflow zone should take the way of prevention. The mining operation under the backing water pressure head of the Ordovician aquifer may be used in the mines because the occurrence of karst water and its movement are different from that of the iron mines. They are not situated in closed underground reservoir. It is not realistic to form a depression cone to mine in such a big range. The way to drain off karst water greedily and cause water level drop greatly is not quite different from making the karst spring complex remove to the mining area. And what is more, the drainage rate would be much more than that of springs. Not only should the large amount of static water be dewatered, but the groundwater after the withdrawal of the divide. In the Heilongdong system, the average discharge is over 20~30 cubic meters per second and the discharge will be up to 50~100 cubic meters per second during the flood period . It is not economically and feasibly considered to take such a means. Furthermore, it will cause exhaustion of the water resources in the system. So the full use of confining bottom of the coal bed and the upper weak aquifer of Ordovician can be made by means of grouting to block the water passage and strengthen the confining bed with necessary drainage measures and engineerings. Thus exploitation under backing water pressure head must be and can be adopted. Of course, there are a number of reservoirs with good quality of groundwater in the area that can be used as the base of

water supply source. Pumping from them can also benefit the mines.

CONCLUSION

The comprehensive water regulation is of great importance to the development of industry and agriculture in the Han-Xing District. The methods having been used are not suitable for this district. This paper raise new tactics in accordance with the hydrogeological characteristics of karst water system in the Han-Xing District. It should be considered feasible.