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THE ELEMENTAL HYDROGEOLOGICAL CHARACTERISTICS OF COALFIELDS IN CHINA & THE PROBLEMS OF PROTECTING AGAINST MINE WATER

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ABSTRACT

According to the geotectonic backgound, regularities of coal accumulation, hydrogeological conditions, and in consideration of the protecting methods against mine water, China's coalfields can be classified into six hydrogeological type regions. This paper emphasizes on the coalfields of Permo-Carboniferous in North China and late Permian in South China, which are of complex hydrogeological conditions and serious disaster from mine water. The basic characteristics of hydrogeology were analysed and the technical methods of protecting against mine water were presented.

China abounds in coal resources. The coal-bearing area are distributed extensively all over the country. Since Cambrian the stone coal deposited till Quaternary the peat deposited, there are more than ten coal-accumulating periods. Among others, the Permo-Carboniferous and Jurassic are the main periods.

Geotectomic background controlled the distribution, the forming periods, the sedimentary environment and different patterns of coalfields, as well as their various hydrogeological characteristics. To the north of Tianshan-Yinshan latitudinal structural zone, where deposited the late Jurassic-early Cretaceous terrestrial coal-bearing strata within the district of Northeast China and eastern part of Inner Mogolia Autonomous Region. Within the bounds to the south of Tianshan-Yinshan latitudinal structural zone, to the north of Kunlun-Qinling latitudinal structural zone and to the east of Helianshan longitudinal structural zone where deposited the Permo-Carboniferous coal-bearing strata with marine-terrestrial alternating facies and terrestrial facies. To the south of Kunlun-Qinling latitudinal structural zone and to the east of Kang-Dian old land, that is the coal-accumulating area of south China, where deposited coal-bearing strata of transitional facies in Permian. Some huge coal-bearing basins were formed in Jurassic period in Northwest China. In addition, the coal-bearing strata of Mesozoic and Cenozoic were deposited in Yunnan-Tibet and Taiwan respectively(1). The geological and hydrogeological characteristics of these coal-bearing areas mentioned above are different from each other. In consideration of meeting the demand for protecting against mine water, China's coalfields can be classified into six hydrogeological type regions correspondingly(Fig.1). i.e., the porous-

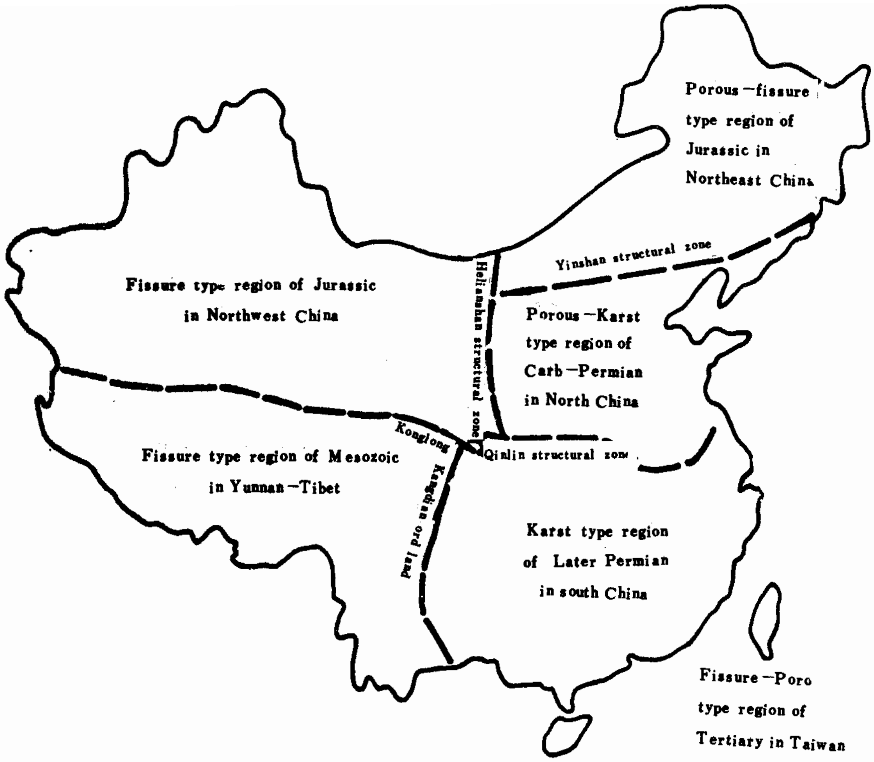

Fig. 1 Sketch of hydrogeological type regions in China

fissure type regions of Jurassic coalfields in Northeast China, the porous-karst type region of Permo-Carboniferous coalfields in North China, the fissure tyoe reguon of Jurassic coalfields in Northwest China, the karst type region of late Permian coalfields in south China, the fissure type region of Mesozoic coalfields in Yunnan-Tibet, and the fissure-porous type region of Tertiary coalfields in Taiwan.

Among them, the hydrogeological conditions of coalfields in North China and South China are the most complex, so that coal mines usually suffered from serious karst disaster. Three main problems on hydrogeology often occurred in these areas: 1. Mine water disaster from Ordovician limestone (known as the Majiago) underlying the Permo-Carboniferous coal seams in North China. 2. Mine water disaster from Cenozoic porous aquifers in the area of Yellow-Huai rivers alluvial plain. 3. Mine water disaster from low Permian (known as the Maoko limestone), underlying the coal seams and from Triassic (known as the Changxing limestone), overlying the coal seams of late Permian in South China.

The disasters from surface water body and Quaternary aquifers are also occurred in Jurassic coalfields in Northeast China. The Jurassic coalfields in Northwest China situated in arid and semiarid regions, which possessed serious difficulty in water supply for coal mine regions.

This paper emphasizes on discussing the hydrogeological characteristics and protecting against mine water in North China and South China as follows:

Mine water disaster from Ordovician limestone underlying Permo-Carboniferous coal seams in North China

Within this extensive area, Permo-Carboniferous coal-bearing strata consisting of Taiyuan and Shanxi members overlay on the Ordovician limestone, Taiyuan member is of marine-terrestrial alternating facies, and Shanxi member is of terrestrial facies in dominant (Fig.2). During the long course of coal mine exploitation in North China, the karst water inrushed frequently from limestones intercalated in Taiyuan member and from Ordovician limestone, so that the karst water hazard became a very serious problem in this area. Except for the north piedmont of Qinling and south piedmont of Yinshan, limestones intercalated in Taiyuan member are gradually changed from north to south. The total thickness range from 5 metres to 60 metres and more (2). The number of limestone layers can be counted from 2-3 beds up to more than 13 beds.

Since the founding of PRC, the Institute of Coal Geology, CCMRI, has cooperated with coal industrial enterprises in drawing and depression, grouting curtain for cutting off underground water routes etc. At present, some well-consideral means for solving the disaster of karst water from limestone interlayers are adopted.

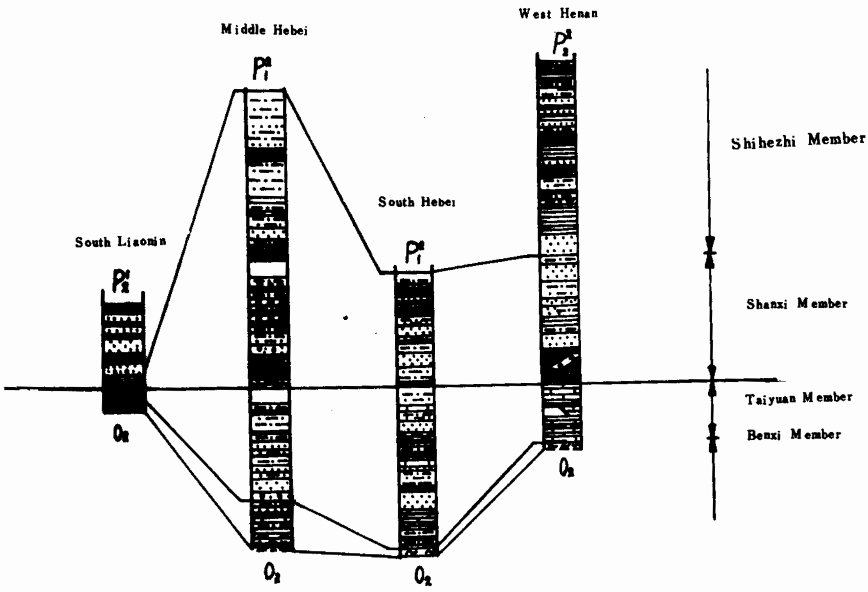

Fig.2 Column of coal-bearing strata of Carb-Permian in North China

In North China, the ingression occurred in early and middle Ordovician , so that the neritic facies carbonatite extensively deposited in this area. Known as the Majiago limestone (Fig.3). Except for a great many of shale instead of limestone at the west edge, the lithofacies is quite stable. Its thickness can be reached 500-600 metres in general. According to the difference in water-bearing degree, Ordovician limestone could be divided into three groups and eight beds. By an incomplete statistics, the total discharge of karst springs is more than 120 m^3/s. In addition, a large number of karst flow submerged into Yellow-Huai rivers alluvial plain. In the course of coal exploitation, the karst water accessed to mine with a large yields. A part of data were arranged in table 1.

Table 1

Coal field	Date of inrush	Datum level	Yields(m^3/min)
Zhibo	1958.4	-145	77
Feicheng	1969.6	-49.5	27
Xingweng	1971.10	-10	32
Zhaozhuang	1966.6	+1	25.3
Laiwu	1963.7	+106	177
Huaibei	1973.5	-250	10
Huainan	1977.11	-235	11
Kailan	1984.10	-310	770
Fengfeng	1960.1	-102	150
Jiaozhao	1979.3	-195	240
Huobi	1981.3	- 30	210
Pindinshan	1971.10	-275	70
Hancheng	1976.8	+240	99.3

One of the causes which led karst water inrushes is induced by the impermeable layers between the low workable seams and top surface of Ordovician limestone is not enough thick to resist water pressure from floors. The another cause is the well-developed small size faults. Fig.4 shows that the thickness of relative aquiclude between low workable seams and top surface of Ordovician limestone is about 25-45 metres in the coalfields satuated at east piedmont of Mt. Taihangshan, 45-95 metres at the south piedmont of this mountain, 75 metres in Houlenshan coalfields, 25-65 metres in central and southern Shandong province, 65-75 metres in North Jianshu province and Northern Anhui province, Until now, with the exception of most coalfields operated above karst water table in Shanxi Province, the water pressure acting on the floor of low workable seams is over 15-25 kg/cm in general, and even more than 35 kg/cm in some deep mines(3). In the course of developing and mining, the high pressure water can often overcome the resistance existed in structural plan of rock body, while under the help of mining pressure, which can lowered rock strength in certain deep, inrushed along the weak zone from bottom into mines. The enormous water flows usually resulted in flooding mines or forced to dewater in a large amount.

Since the founding of PRC, the method of grouting to seal the inrush spots from boreholes are usually adopted by coal mines, but it is until now that we can't change the passive situation caused by frequent water inrushes yet. Since the sixties, drawing and depressing for Orcovician limestone, both from ground surface and uncerground had been carried out. For example, in

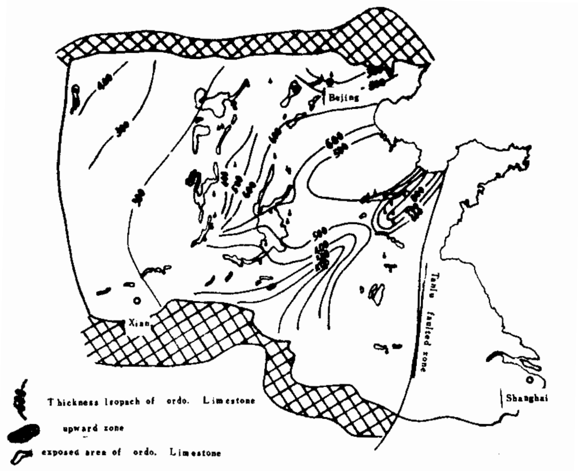

Fig. 3 Sketch of hydrogeology of Ordo. Limestone in North China

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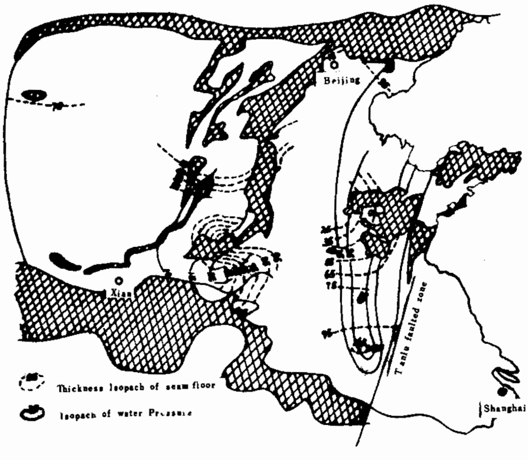


Fig. 4 Sketch of water disaster from Ordo. Limestone

0 300 600 900 KM

1965, releasing water tests with a discharge of 3 m /min, had been carried out in Wangfeng coal mine situated at the east piedmont of Mt. Taihangshan. However, the water table did not fluctuate. In 1978, the multiwater well pumping test with 50 big diameter wells was carried out in the same coalfield, as a result, when the discharge attained 88 m /min, the center of the depression cone droped merely 3.5 metres. It is conceivable that dewatering as a unique way in this region is not an economical method. In the meanwhile, we had maken great effort to study on the machanism of floor inrudhes, in order to forecast and adopt some preventive measures(4). Then, a series of examinating and observing for impermeable layers, faults and mine pressure were carried on. Grouting to from underground curtains for cutting off water flow and form prevence anti-seepage layers under the coal seams, had also been completed. All of these have brought about corresponding effecta, it will tend towards more perfected along with the development of protecting against mine water.

Then, we can come to the conclusion that the problems of soling Ordovician limestone disaster should be guided under the overall plane of water contrølled in mine regions, so as to take the technical measures with comprehensive methods.

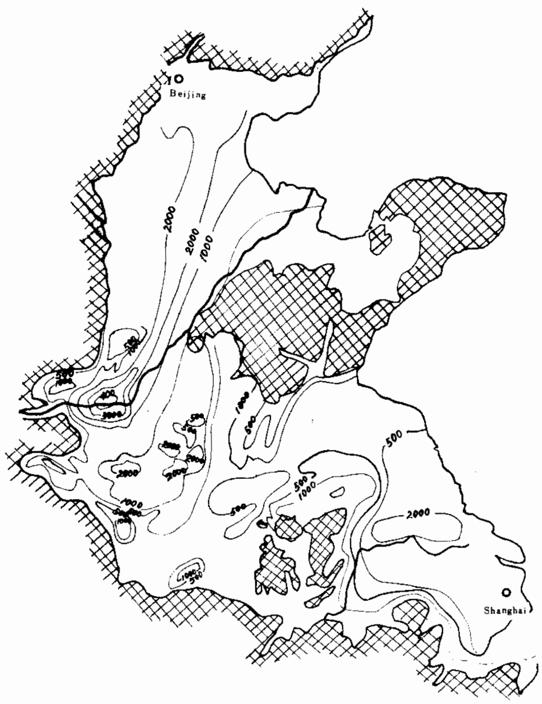


Fig. 5 Isopach of thickness of Cenozoic Era in Yellow -Huai plain

0 40 80 120 KM

Mine water disaster from porous aquifers of Quarternary in Yellow-Huai rivers alluvial plain

Since Tertiary period, the Mt.Yinshan and Mt. Taihangshan uplifted successively and Yellow-Huai plain subsided rapidly. Simultaneously,a large number of lake basins formed thereafter and Tertiary strata with a large thickness was deposited therein. The embryonic form of Yellow-Huai plain was portraied by middle Pleistocene(5). Yellow river and others flowed through Mt. Taihangshan and Mt. Yinshan,thus, it brought a large quentity of sediments material from Loess plateau and Shanxi-Inner Mongolia mountain into the plain, thus, a series of diluvial-alluvial fans were formed. The thickness of Cenozoic strata was controlled mainly by the basemental tectonics orientated NNE. The maximum thickness would be reached 4000 metres(Fig.5). From Tertiary to plocene, red strata of terrestrial facies, in which the petriclastic sediments with basalt intercatation are predominant, was deposited. During the Pleistocene-Holocene, different lithofacies of unconsolidated rocks consisting of valley flat, river channel, lacustrine, lagoon and residual facies were formed. The thickness tends to be 100-200 metres. It can be divided to four cycles of sedimentation. The bottom of each cycle were sand, gravel or clay with intercakation gravel, and the sediments were getting fine upward(Fig.6). The

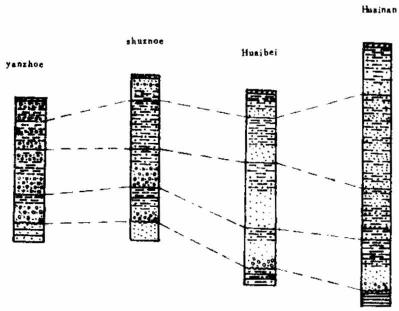


Fig. 6 Cycle of sedimentation in Quaternary in Yellow-Huai Plain

thickness of sand and gravel layers, which much rich in water, is about 35-55% of total Quaternary strata. Especially, the water-bearing sand layers are possessed of fluidity and adhesion, so that the water with running sand inrushed into mine frequently in the course of mining.

Sice the founding of PRC, many researches works dealing with roof rock strength, stress and strain, strata movement and the destory rules of rock cover, have been completed, so that many available data are accumulated. In general,it can be kept enough roof pillars for protecting against water inrushes. In mining costruction, it can be taken the methods of freezing or shaft-sinking by big-hole drilling to through the running sand layer.

However, there are still two problems to not be solved. One is how to reduce the pillars for preventing roof water, which are more than 30 million tons in each mine with water disaster. Another problem is water supply for coal regions, where mine dewatering have to avoid to destory the agriculture wells, which pumped water from upper aquifers. Only lower the water pressure for bottom aquifer of Quaternary, so as to solve the problems of water inrushes and water supply.

Mine water disaster from Permian and Triassic limestone in South China

The late Permian coalfields are distributed extensively in South China, of where, coal reserve amount to 4.6 per cent of the total in the country(7). Comparatively speaking, this pattern of coal is merely a small number of reserve, but it is still an important bearing-coal strata in South China. The distribution limestone (known as Maoko), is shown as Fig.7, which tends to be 200-400 metres in thick underlying the coal-bearing strata, and the distribution of Triassic limestone (known as Changxin), is shown as Fig. 8, which tends to be 50-200 metres in thick overlying the coal-bearing strata. Both the limestones are aboundant in karst water, and the main aquifers for mines, so that the hydrogeological conditions are very complex.

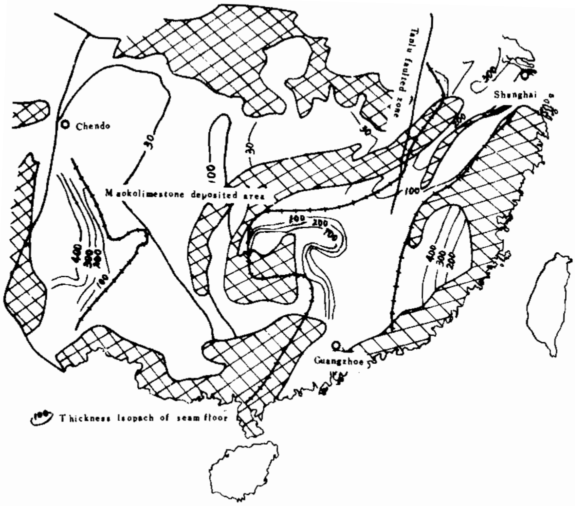
In the area of Maoko limestone deposited, therelative impermeable layer between workable seam and the top surface of Maoko limestone, is less than 10 metres in general. However, some regions such as central Hunan coalfields are merely with clay of 0.1-0.3 metres. The karst water inrushes occurred just there from (Fig.7). In the area of Changxin limestone deposited, the relative impermeable layer between workable seam and the bottom surface of Changxin limestone is ranged from 15 to 25 metres, moreover, some regions such as Pinglao Subsidence Zone is less than 10 metres. So that, accidents of karst-water inrushes from roof occurred frequently.

The coal mines sufferes with karst-water disaster in South China are belonged to small scale in common, whereas, the mine water dischange is often considerable. The data of some representative mines are listed as table 2.

Table 2

Province	Designed capacity (T/Y)	Discharge (m^3/min)	Data	Aquifer
Hunan	15	54.1	1976.9	Maoko
Jiangxi	15	166.6	1974.7	Changxin
Guangxi	30	48.3	1976.6	Maoko
Sichuan	30	138.3	1968.5	Maoko
Guangdong	10	11.6	1978	Maoko
Guizhou	30	26.6	1974	Maoko

During the course of dewatering for a long duration, the underground water table lowered with a large range, and then, in the influence depression, it gave occasion to collapse holes of Quaternary covering. This kind of holes have a diameter ranging form several metres to tens, which caused fields collaped, houses caved in, rivers broken off, traffox cut out. For instance, there are 850 collapoe holes caused by dewatering at one coal mine in Hunan Province. Seeing that coalfields



Fig·7 Sketch of water disaster from Maoko limestone in South China

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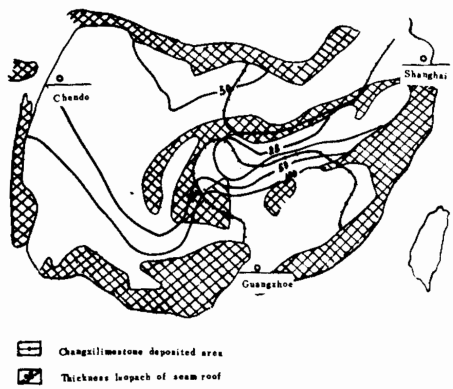

Fig. 8 Sketch of water disaster from Changxi limestone in South China

0 1800 KM

threatened by karst water possess the character for thin impermeable layers, rich water aquifers, large precipitation, many ground water bodies, small coal outpost, large discharge, and serious collapse etc. Then, the anthor has advanced the concept and method of controlling over mine water flow in 1971. This is an artificial method of controlling over the fluctuation of dischange, and take aquifers as a underground reservoir to regulate the underground water(8). According to the result of tests in Hunan coal mines, it can be decreased mine discharge by 30 m^3/min and make up about 42% of the total dischange. The method of controlling over mine water flows not only can dispel the flood peak of discharge to ensure the safety of mine in rainy season, but also can maintain a low discharge in dry season. Discharge controlled and reasonable dewater may close a large number of underground water in aquifers to reduce the depression cone. Thus, the problems of surface collapse may be solved partly. In the meantime, according to various conditions, auxiliary measures, such as, alterating the location of dewatering tunnel, consolidating the impermeable layers of seam floor, reducting the permeability of aquifers at the boundary of mine regions, to keep reasonble pillars etc, have been used. Henceforth, we will test continuously to improve the method of controlling mine water flow.

Except above mentioned, there are two glaring problems of hydrogeology. One is the problem of water supply in arid and semiarid regions in Northwest-North China, another is the problem of protecting against water for open cut mine in northeast China and the Eastern Inner Mogolia. In the arid and semiarid regions, the precipitation tends to be 100-250 mm, only, the surface water bodies are not developed, aquifers are dificient in Jurassic coalfields, and the karst water level is more deep in Permo-Carboniferous coalfields. So that the water supply have not been solved better in most coal regions. some of open cut mines are being developed in Northeast China and Inner Mogolia are possessed of much rich Quaternary covering and are influenced by rivers. So that it can not be solved only by dewatering, must be done certain hydrogeologic study to make sure the main route of underground water, so as to take measure of cutting flows.

Above discussing the elementary characteristic of hydrogeology, the main problems, the present situation and the further works. We wish to strengthen the exchange and coperation with foreigh colleagues.

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List of figures