THE HYDROGEOLOGICAL DIVISION AND CLASSIFICATION OF COAL MINES IN CHINA

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ABSTRACT

China is a country with a vast territory, where the hydrogeological problems are very miscellaneous. In order to make hydrogeological work of coal mines scientific and systematized, to carry out hydrogeological work aimed at coal mines with different hydrogeological characteristics and to difine the task and direction in each coal mine, it is needed to establish work standards according with the reality. For this purpose, it is extremely necessary to classify China's coal mine hydrogeological conditions by regions and classes. The paper has given a good resolution for the hydrogeological classification of China's coal mines. The comprehensive classification project put forward by the author was adopted in Regulations of Hydrogeology in Coal Mines (trial) issued in 1984 by the Ministry of Coal Industry of China.

INTRODUCTION

The nature of hydrogeological work in coal mines is different from both that of regional hydrogeological survey and that of coal exploration phase. Its target of study is water-charging regularity of space constituted by roadways and shafts as well as worked-out area (relationship between mining activities and factors of water-charging in different coal mines and conditions for different kinds of water to enter into roadway, shaft and worked-

out area) rather than aquifers and their water replenishment conditions. Its purpose of study is not only to define hydrogeological conditions but also to serve coal production and construction by controling water hazards according to water-charging regularity, protecting and utilizing underground water resources on the basis of hydrogeological conditions defined in coal exploration phase.

According to the differences of water-controling methods and hydrogeological and water hazard characteristics, the paper divided hydrogeological regions of China's coal mines into three large regions (the North, South and West of China) and eleven types.

THREE LARGE REGIONS-FIRST LEVEL CLASSIFICATION

1. The North of China. This region is located on the north of Qinling Mountain Chain to Huaihe River and on the east of Daxin'anling to Liupanshan Mountain Chains, and with North China's Plain and North-East China's Plain as its principal parts, including some plateaux and hilly country as well as mountanous areas. In view of administrative division, it includes Heilongjiang, Jilin, Liaoning, Hebei, Shandong and Henan Provinces, the north of Jiangsu Province, the north of Anhui Province, the south of Shanxi Province, the Guanzhong area of Shaanxi Province, etc. The region is in temperate and medium temperate zones with the continental monsoon climate. The annual rainfall is from 500 to 900 mm. Majority of rivers are seasonal and high water season is short, and there are few of surfacial water bodies. Moist coefficient ranges from 0.3 to 0.6. Coal-bearing measures are constituted principally by Permo-Carboniferous systems. The scale of coal-accumulating basins is very large and the folds are relatively smooth. Majority of coal-accumulating basins are situated in large plains and they formed monoclinal and synclinal water-storing structures of large scale.

2. The South of China. This region is on the south of Qinling Mountain Chain to Huaihe River and on the east of Qingpang Plateau. It is constituted principally by hilly areas and plains,and includes some basins and plateaux. From administrative division, it consists of all provinces to the south of Qinling Mountain Chain and Huaihe River, and Guizhou, Sichuan, Yunnan, Taiwan provinces, etc. Geographycall, it is located in tropical zone and subtropical zone with subtropical monsoon and damp climate and tropical monsoon climate. Rainfall is abundant and annual rainfall ranges mostly from 1200 to 2000 mm. Drainage systems are very developed and a great number of reservoirs and ponds existe everywhere. Moist coefficient is bigger than 1.Coal-bearing measures of south facies are constituted principally by Longtan coal measure. Coal-accumulating basins are present in some intermontane basins, fault-block basin and elongated folds of which the scale is small. Tectonic activities are intense. Coal fields are located in hilly areas of plateaux or lower hilly areas, and have formed some small water-storing structures.

3. The West of China. This region is on the west of the North of China and on the Northwest of China. It has loess plateau and Inner Mongolian Plateau as well as hilly areas as its main body, and includes some basins and valley plains. Administratively, it comprises all provinces of the Northwest of China, the Tibet Autonomous Region, the Inner Mongolia Autonomous Region, the north of Shanxi Province, the north of Shanxi Province, etc. The region is located in medium temperate zone and temperate-frigid zone. Annual rainfall is below 400 mm (except in the southeast of Tibetian Plateau) and ranged from 50 to 200 mm. It is of continental temperate climate. It is arid in dry seasons with heavy evaporation. Of rivers most are inner ones, and there are rare surfacial water bodies. With a moist coefficient less than 0.29, it is dry and semi-dry region. The tectonics of coal-accumulating basins on the east of Helanshan Mountain Chain are similar to those in the North of China. But on the west of Helanshan Mountains the formations are of Mesozoic geosynclinal deposits of which the majority are Jurassic coal-bearing measures.

Table 1. Hydrogeologic division and classification of China's coal mines

content \ region types		The North of China		
		simple	medium	complex
aquifers destroied or influenced by mining activities	characteristics of aquifers	aquifers of pore and fissure	aquifers of pore, fissure and karst fissure	aquifers of karst fissure caves, those with drift sand or gravel
	specific capacity q = 1/s.m	$q < 0.1$	$0.1 < q \leq 2$	$q = 2\sim30$
main water-charging sources and its abundance of water for mines		Precipitation and phreatic water. The outcrop zone of aquifer overlaid by argillaceous bottom. Aquifer dissected and confined by faults. Good water-draining conditions on surface. Poor conditions for water to enter mines, and small amount of water.	Precipitation and phreatic water. Mediocre conditions of water entering into the mines; relatively big amount of water.	Precipitation phreatic water or water conducted by fracture zones; complex water sources; good water-charging conditions; big amount of water.
discharge of individual mine m^3/h	annual average	< 180	180~600	600~1800
	maximum	< 300	<1200	1200~3000
effect of water hazards on mining and excavation		excavation very less influenced by water hazards	water hazards influence mining but doesn't threaten the safety.	severely influenced, sometimes mines are flooded.
level of difficulty for water-control		simple	relatively simple	difficult and complicated

Note: 1. The discharge of mines mining Tertiary seams with drift sand isn't involved in the table.
2. Individual mine refers to a production mine rather than a mouth of shaft.

Continued

	The South of China		
very complex	simple	medium	complex
Aquifers of karst caves and fissures	aquifers of pore fissure and karst fissure	pore, fissure aquifers and karst aquifers	karst fissure-karst cave aquifers or drift sand aquifers
q>30	q<0.1	0.1<q≤2	q<30
Water directely or indirectely from lower Ordovician karst caves aquifers; Frequent hazards due to water of high pressure which break the floor of coal seame, and goes in mines through faults or fissure zones. Very big discharge.	Precipitation; good draining conditions, poor water-charging conditions; small amount of water to enter mines.	Precipitation and surface water; good draining conditions; less surface water bodies; poor water-charging conditions due to overturning which made Changxing limestone the floor of coal seams; less water inrush-prone; water to enter mines is relatively abundant	Precipitation and karst underground rivers for mines in hilly areas or plateaux, precipitation and surface water bodies for mines in hilly plains; good water-entering conditions; big amount of water.
> 1800	< 180	180~600	600~2100
> 3000	< 300	< 1200	1200~3000
severely threatened, mines are often flooded.	very little influence	water hazards influence excavation but doesn't threaten the safety.	water hazards threaten the excavation and cause casualties.
very difficult even no possibility for permanent control	simple	easy	relatively difficult, a lot of work needed to control water and karst subsidence.

Continued

	The West of China		
very complex	simple	medium	complex
karst underground rivers or karst cave aquifers	pore fissure aquifers	pore and fissure aquifers	sand and gravel aquifers
q≥100	q<0.1 K<0.1	0.1<q≤6 K>1~10	q≤30 K = 30~100
In mines in hilly areas or plateaux, or in synclinal positive landform, karst caves and dolines can be found everywhere, forming a lot of underground river systems charged by water from precipitation and surface rivers which has converged at first in water-collecting depressions; sharp rise and drop of level after torrential rain. In hilly areas and plains, precipitation and surface water are major water sources for mines; river and rivulets developed; a great number of pools and reservoirs; good conditions of water-interconnection; karst developed; extremely abundant water.	Precipitation; small rainfall; small amount of water entering mines.	Charged by precipitation or by penetration of surface water bodies; relatively abundant water.	Charged principally by water from unfreezed sand and gravel layers or thick sand layers; big amount of water produced by mining.
1200~3000	0~100	100~150	300~1200
> 4000	0~300	120~300	600~3000
Frequent water-inrush with tremendous force and silt threaten the excavation and often flood the mine.	very little influence	The excavation is influenced but mine isn't threatened.	The excavation is severely influenced and the mine is flooded sometimes.
So difficult and expensive that it makes the mining economically unreasonable.	simple	Servey and prevention of potential water as well as project to control seepage are needed.	Relatively difficult, volumed water-control projects are needed.

BASES OF CLASSIFICATION OF THREE REGIONS

1. The nature of hydrogeologic work in coal mines. Hydrogeology in coal mines aims at underground hydrogeological problems. It is carried out and developed with the mining activities. Its principal object of study is the water-charging regularity of mines -- relationship of mining activities with different water-charging conditions and conditions of water from all sources getting into shafts or worked-out areas -- rather than aquifers and their replenishment conditions. In production mines, the space filled with water is shafts and roadways rather than pores, fissures and karst caves. Beside, water-storing rocks in three regions, even they possess the same nature, show evident difference in water saturation and effect on mines due to their differences of geographical location.

2. The difference of geographical situation. Ground water and surface water form an inseparable entity. In this meaning, the difference in natural geographic conditions reflects substantively the difference of underground water-forming conditions. The climate is the most significant factor which characterizes natural geographic situation. It affects very much the formation of groundwater in a mine or an area. As the root of the matter, the original source of groundwater is precipitation. Therefore, rainfall and moist coefficient can immediately reflect best the forming conditions of groundwater especially phreatic water. China is a country with vast territory, crossing five temperature zones from the south to the north. All of these cause a great difference in natural geographic conditions in the three regions. Annual rainfall and moist coefficient of a region differ a lot from the others. In the South of China, the annual rainfall ranges from 1200 to 2000 mm, and the moist coefficient is bigger than 1; while in the North, the former is 500-900 mm and the latter 0.3-0.6; and in the West, they are respectively under 400 mm (gene-

rally, 50-200 mm) and smaller than 0.29. Thus, by using three large regions as criteria of first level classification based on natural geographic conditions, the regional hydrogeological differences in China's coal mines can be distinguished according to the groundwater-forming conditions which are the key of the problem.

3. The difference of basic factors to form deep groundwater in mine area. The basic factors to form deep groundwater, as stated in the paper, refer to the geological and structural characteristics of coal-accumulating basins -- structural form of coal-bearing measure and coal basins. The characteristics of aquifers in mine areas depend on coal-bearing strata, while the scale of water-storing structures and the conditions of displacement are determined by structural form of coal basin. In the South of China, the major formation consist of Palaeozoic Permian Longtan coal measures. Generally, the overlaying and underlaying layers of seams or coal measures are composed of marine beds constituted by thick carbonate rocks. Folding has been intense and formed small water-storing structures. Because it is a hilly region, covering topsoil is very thin or lost. Therefore, deep groundwater and phreatic water as well as surface water are very close and charge each other. With favorable conditions of displacement for deep groundwater, mine areas have very developed karst by which coal mines are seriously threatened.

On the contrast, in the West of China, the greater part of strata consist of Mesozoic Jurassic coal measures deposited on old bed rocks. The coal measures are all continental sediments in interior segs and are principally composed of basal conglomerate, siltstone, kerogen shale, aluminous mudstone and interbedded sandstone and mudstone. Water storage capacity is poor (most of strata are impermeable or weakly permeable). It is only in deep valleies and valley basins that can be found relatively abundant water. So, generally, the water-make is small in mines.

In the North of China, coal measures show a different feature. The lower part of coal measures is composed of marine-continental interbedded Carboniferous strata, underlaid by thick middle Ordovician limestone. Middle Palaeozoic strata are lost completely. The folding has been smooth and formed some water-storage monoclines and synclines of large scale. The upper phreatic water is often hydraulically related to deep groundwater and both recharge each other. The discharge of aquifer in monocline and syncline of more than 1000 m decreases with the deptn and there exist different vertical zones. In other coal basins, the outcrops of seams are overlaid and confined by Quaternary argillaceous soil or the shallow part of aquifer is cut and confined by impermeable faults. Under these conditions, little amount of water is recharged to deep aquifers in coal basins.

FIVE CONDITIONS FOR CLASSIFICATION OF TYPES

The purpose of classification of hydrogeologic types of coal mines is to distinguish coal mine according to complexity of hydrogeologic conditions. The project presented in the paper divided a vast region into three or four types (simple, medium, complex, very complex). The simple way to estimate the complexity of a mine is to consider how the water-make is and how difficult the water-control is as well as whether the mine is flooded. The paper proposed two other criteria -- the character and water capacity of aquifers destroied or affected by excavation as well as the main water sources and their amount of water going in mines -- as additional analytic contents. These five conditions have constituted the bases for the project of the divison of types suggested in the paper.

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