BASIC HYDROGEOLOGICAL CHARACTERISTICS OF THE COAL DEPOSITS IN CHINA

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ABSTRACT

Based on architectonic, minerogenetic epoch, physiographic conditions and others, this paper states basic law and control factors of hydrogeology for coal deposits in China. Then, it shows multiplicity and complexity of the hydrogeologic conditions. An area separation is made for the hydrogeology. Readers well have primary understandings of hydrogeologic conditions for coal deposits in China from this paper.

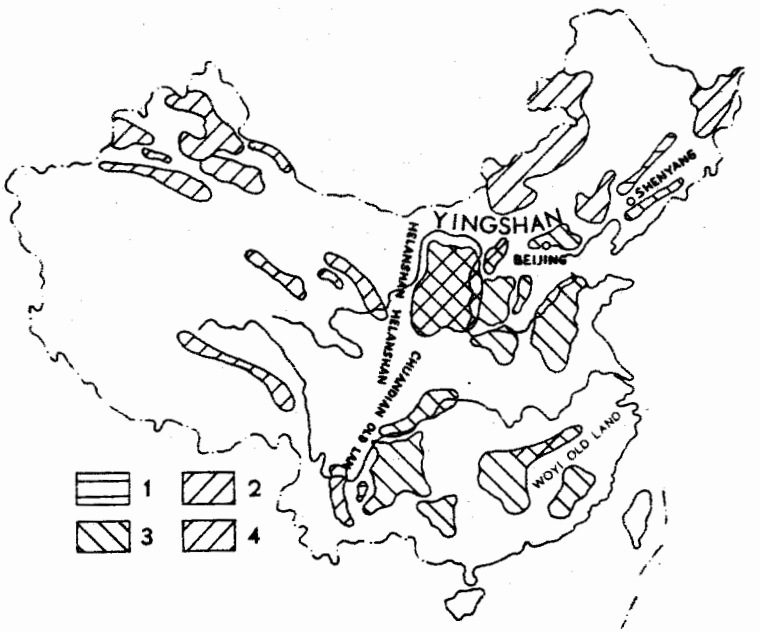
China is very rich in coal resources with all kinds. The coal resources are widely spread over the country. The conditions of hydrogeology for coal deposits are multiplicity and complexity. Since 1984, the coal product of China has been become the second largest in the world. During the exploration and mining of coal, ot has occured with lot of problems of hydrogeology and learnt lot of experiences and lessons. Obiously, to sum up and introduce the basic characteristics and law of hydrogeology for China coal deposits will be benefits to the exploration and mining of coal beds and the scientific research on underground water.

1. KARST WATER, SPECIALLY KARST WATER UNDER SEAM FLOOR IS THE MAJOR DAMAGE TO COAL MINES IN CHINA.

The area for limestone spread over China is up to 2 million square kilometers. This formed depositional bases for most coal fields in Late-Palaeozoic and also for a small part of coal basins in Mesozoic Era and Cainozoic Era. In some coal fields, marine and terrestrial alternating coal measure stratum often intercalated with many limestone beds. Some coal measure stratum are under thick limestone beds and some in the between of limestone beds. In some coal fields due to results of multi tectonic nappe, coal measures and limestones were in interbedding. Due to shearing effect of the faults, some coal measures are connected with limestones.

Those limestones very rich in water but not homogeneous, it caused great difficulties to coal mining and exploration. Coal mining in such coal fields will have a large quantity of mine water and intrushing water from tens cubic meters to several thousands cubic meters per minute. The inrushing water not only caused to mine flooded, but hard to develop and make use of those a great deal coal resouces. To mining those coal fields, it often causes surface subsidence with a larger area or shallow water source dried up. Such problemes had occured at many mine areas in China.

Coal deposits with karst water are widely spread over China, except a few provinces in north-east and north-west of China. Specially, the karst water in seam floor are most widely spread over China. Including in the area within south of Yinshan and Shenyang line, east of Helanshan, Liupanshan and Chuandian old land line, and west of Wuyi old land, most Palaeozoic and some Mesozoic coal fields in this area (Fig. 1), specially in Jiaozuo, Hebi, Fengfeng, Jingjing, Kailuan, Huoxian, Hancheng, Chenghe, Zibe, Feicheng, Meitanba, Duolishan, Enkou, Yunhuqiao, Heshan and other mines, there have floor water problems which are most serious and complicated.



1. Neozoic Era coal field
2. Mesozoic Era coal field
3. Palaeozoic Era coal field
4. Mesozoic and Palaeozoic Era coal field

Fig. 1. Major coal fields distribution sketch map of China.

Those high pressure karst aquifers under the seam floor are Ordovician limestones in north part of China and Maokou limestone in south part of China. In coal mining, high pressure karst water will often break through floors of mining section or drift, and through faults, karst sink-hole and other water channel, it rushed into mines. For example, high pressure karst water through a karst sink-hole rushed into a mine, called Fangezhang mine, Kailuan coal mine bureau in 1984. The max water flow was up to 2053 m^3/m. This inrush not only quickly made the mine flooded and had a dangerous to the neer mines. Ordovician limestone water under seam floor rushed into a mining section at Beidajin mine, Zibe in 1935, the water inrush was about 443 m^3/m. This inrush not only quickly flooded the mine, but killed 536 lives. At Magouqu mine, Hancheng, the limestone water under seam floor was bursted into the mine with a flow over 200 m^3/m in 1976. This water burst flooded all levels below a 380 level. It is not recoved now. The karst water under seam floor bursted at 240 m^3/m into Yanmazhuang mine, Jiaozuo in 1979. this mine was all flooded. It is too numerous to mention individually for those water problems due to too much water bursts at water flow from 10 m^3/m to 100 m^3/m.

In the sthuggle against karst water, specially karst water under the seam floor, we have primaryly studied and learnt the mechanism of floor-heave water. It has successfully predicted and prevented floor-heave water in Zibe mine and other mines. We have successfully controlled a special water burst with 2053 m^3/m in Fangezhuang Mine, Kailuan. Apressurized coal mining has been conducted or being conducted in some mines with large quantities of karst water. A work to relieve coal resources from a danger of karst water is being conducted in several mines. Advanced different means with high efficiencies and a set of exploration methods in line with local conditions are used for the exploration of karst water. However, a struggle against karst water is still a major project which is to be further studied and solved in the science and research on hydrogeology of coal deposits in China.

2. AS A DIFFERENCE IN MINEROGENETIC EPOCH, THERE IS AN OBVIOUS DIFFERENCE IN HYDROGEOLOGICAL CONDITIONS OF COAL DEPOSITS.

In China, there were coal deposits from Proterozoic era, Palaeozoic era, Mesozoic era to Cainozoic era. Among there deposits, most were come from Carboniferous Period and Permian Period in Post-Palaeozoic, Jurassic Period in Mesozoic era, and Tertiary Period in Cainozoic era.

Due to a different minerogenetic epoch for each coal field, there is an obvious diffence in each hydrogeological condition. This is another characteristic of the hydrogeology in Chinese coal fields.

Coal fields in Post-Palaeozoic era are mainly with karst water and second with fissure water. Coal fields in Mesozoic era are mainly with fissure water and second with void water. Coal fields in Cainozoic era are mainly with void water and second with fissure water. This characteristic is caused by some certain geological histories in China.

On North China Area at Early-Palaeozoic era, there was a wide steady epeiric sea which was mostly deposited with limestones in Cambrian System and Ordovician System. At time of Caledonian Movement, the whole area was rised to be a land. This caused mostly karst with the limestones in Cambrian System and Ordovician System. Untill middle Carboniferous Period, this whole area was descended again. Therefore, a coal-bearing stratum in Post-Palaeozoic widely deposited on the karst limestones. This was the nature conition which means karst water is a danger to the coal fields in Post-Palaeozoic at whole North China. Also, due to vibration movements occured at deposition of the coal measures, it caused to deposite multi-layers of limestones with a low thickness and steady spread over. This formed a hydrogeological mode which means coal measures in Post-Palaeozoic at North China area with multi-layer of water bearing limestones mainly with karst water in seam floor.

In South area, coal measures in Post-Palaeozoic Era and carbonate rock measures were crossly deposited. The main coal measure is Longtancoal measures with Changxing limestone at upper level and Maokou limestone at low level. Liangshan Coal Measures is between Chiashia limestone and Huanglung limestone. As for Ceshui coal measures, there is a Zimenqiao limestone at upper level and Shidengzi limestone at bottum level. Above deposits are mainly with karst water.

After Mesozoic Era, most areas in China were rised to be land, except for some coal field directly over laied on a bottom floor of a limestone in Palaeozoic Era (such as coal field in Weixian Hebei and Xainfeng Yunnan), and in some coal fields, coal measure in Mesozoic Era and limestone in Ordovician System are superimposed by nappe structure, most coal fields in Mesozoic Era and Cainozoic Era have no karst water.

Coal fields in Mesozoic Era mainly are with fissure water, but coal measure in an area from north part of Yinshan mountain and west part of Daxinganling mountain are mainly with void water.

As for coal fields in Cainozoic Era, their diagenetic qualities are most lower, the lithological characters are soft and the fissures are undeveloped. They are mainly with void water.

3. DIFFERENT ARCHITACTONIC CONDITIONS FORM DIFFERENT HYDROGEOLOGICAL CHARACTERISTICS IN COAL FIELDS.

The basic architectonic pattern in China is based on great latitudinal structure zones and longitudinal structure zones as the main trunk (Fig.1). The latitudinal structure zones are: (1) Yinshan-Tianshan structure zone and (2) Qinling-Kunlun structure zone. The longitudinal structure zones are Helan-Liupan structure zone and Chuandian structure zone. Taking the longitudinal structure zone as a dividing line between east and west. The east part developed a series of north-east structures (Cathaysian System and New Cathaysian System). The west part developed a series of north-west structures (Xiyu System, Hexi System and Qinzangdian torsion structure). Such basic pattern not only has resolved characteristics for the formation

of coal resources in China, layout with East and West two large areas and North, Middle and South three large zones. Such a pattern also determined a great difference between East to West and North to South in hydrogeological condition in Chinese coal deposits.

Taking Heluan-Liupan and Chuandain structure zone as a line, coal fields in Post-Palaeozoic Era in China can be divided into two different large areas. Most coal fields in Post-Palaeozoic Era are concentrated in the East Area and mainly with karst water. The hydrogeological conditions are fairly complicated or very complicated. Coal fields in West Area are mainly in Mesozoic Era. Post-Palaeozoic coal seames in West Area were generally poor developed, and are only few with a great economic value. The hydrogeological conditions are generally very simple and mainly with fissure water.

By Yingshan-Tianshan Structure Zone and Qinling-Kunlun Structure Zone, the East Area can be divided into three subareas with different hydrogeological conditions.

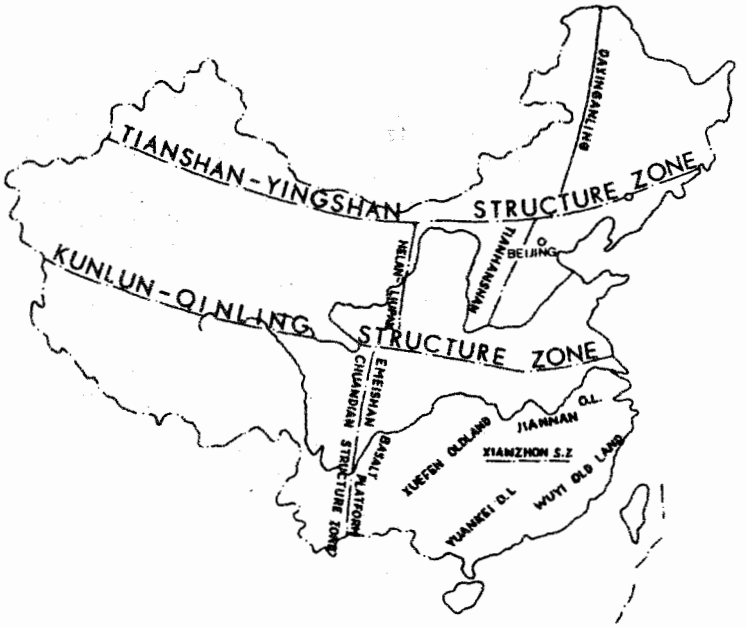


Fig. 2. Diagram of Basic Architectonic Pattern in China.

(A). In the North Subarea, it lacks of a economic value in Post-Palaeozoic coal fields. The coal fields in Mesozoic Era are fairly widely spread over and have no problems with karst water. Due to a difference in architectonic properties for east part and west part in the North Subarea, there is a obvious difference in coal field hydrogeological coanditions for east part and west part. In the east of Daxinganling Mountains Yanshan Movement and Himalayan Movement was quite serious and the structure in coal fields is fairly complicated. Its crack was developed the diagenetic grade in coal measure and metamorphic grade coal seam both are fairly high. Therefore, the coal fields are mainly with fissure water and the engineering geological conditions are fairly simple. In the west part of Daxinganling Mountains, the earth crust is fairly strong in entirety. It had a less effect from Yanshan Movement and Himalayan Movement. Its structure is simple and the declination is fairly slow. The overburden is low in depth. The diagenetic grade in coal measures and metamorphic grade in coal seam both are low. The coal fields are mainly with void water and engineering geological conditions are fairly complicated.

(B). In the Middle Subarea at early Palaeozoic Era, it had formed most important concentrated coal area - North China Concentrated Coal Area in Post Palaeozoic Era. In this coal area, coal measures in Post Palaeozoic generally covered on serious karst limestones in Middle Ordovician System with a parallel and discordant relation. This formed an artesian basin in a large scale. It has a wide area of water supply and is very rich in water resorces. This made coal fields in Post Palaeozoic had a danger from karst water in seam floor. There is hydraulic relations in different grade between multi partings of limestone in Post Palaeozoic coal measures and limestone in underlying Ordovician System through cracks. This caused hydrogeological condition in coal seam more complicated.

(C). In the South Subarea, the coal fields in Palaeozoic are also mainly with karst water. The architectonic properties in this area was not a whole rigid block in Palaeozoic Era. Based on a latitudinal and longitudinal basic pattern, the South Subarea was composed of north-east structures with a series of upwarping region and downwarping region. This formed a paleogeographic landscape with a series of north-east epeiric sea and old land. It caused the coal fields layout and its hydrogeological conditions having a complicated feature with a variation in east and west parts and differences in north and south parts.

In this area, an aquifer which has a great important effect on the hydrogeological conditions is Maokou limestone. The layout of this aquifer and its relation with coal seam is obviously restricted by architectonic conditions.

Maokou limestone spread all an area from east side of Chuandian Old Land, south side of Hueiyang Old Land, along Xuefen Old Land and Xianzhong East-west Structure Zone to the north-west side of Wuyi Old Land. At east and south part of South Subarea, Maokou Limestone has facies changed into Dangz-

hon Group or Gufen Group mainly with silicolites which have no danger to a development of coal fields. At east side of Chuandian Old Land, after the deposition of Maokau Limestone, a great amount of basalts through a large fault from north to south were erupted over Maokou Limestones. At west of east-longitude 105^{0}-106^{0}, there is basalt in a thickness from tens to hundreds meters between Maokou Limestones and upper coal measurea. Therefore Maokou Limestones will have no danger to a coal seam mining.

Another main aquifer up on Longtan Coal Measures is Changxing Limestone which is spread about the same area as the area of Maokou Limestone spreading. At south Xianzhon Structure Zone and east of Wuyi Old Land, Changxing Limestone has facies changed into Dalong Group with silicolites and thin limestones.

The lithological characters and hydrogeological condition of Jiannan Old Land and west part of Xuefeng-Yuankei Old Land, Longtan Coal Measures are often with several thin limestones partings with a medium thickness. Those materials are often with karst-fissure water. At the south of Jiannan Old Land and east of Xuefen-Yuankai Old Land, there is no limestone in the coal measures but with fissure water. At the platform of Emeishan Basalta and its west part, the coal measures has facies changed to continental facies in Xuanwu Group.

The era of the coal measures and hydrogeological condition at east part of Wuyi Old Land is quite different with west of it. This coal measures are not Longtan Measures but Tuanziyei Group in Early Permian and with bradyseism-mutual phase. The underlying Wenbishan Group and upper lying Cuibinshan Group both are clastic rocks in continental facies. Therefore, the hydrogeological conditions are very simple.

Architectonic not only restricted the deposited conditions and area hydrogeological conditions of coal fields in South China, but also restricted the retaining and improving conditions of the coal field and the certain hydrogeological condition in mine areas. After the formation of coal measures in South China, it occured several structural movements, such as Indo-China, Yanshan, and Himalayan Movement. It caused to shear and disintegrate the aquifer and the upper and down lying aquifers into several block section, there, it formed a series of artesian basin and artesian declined land. Although it developed very seriously in karst water, the scale and supply condition of water bearing structure is less poor than North China. In some coal mine, due to nappe structures causing an aquifer which previously has no relations with a seam to be directely on a seam, it makes the hydrogeological condition complicated (Fig.3).

4. PHYSICAL GEOGRAPHICAL FACTORS HAVE VERY IMPORTANT EFFECT ON HYDROGEOLOGICAL CONDITIONS IN COAL FIELDS.

Chinese coal fields are spread over an area about 550 000 km^2 through all provinces and regions. Due to larger area in China, a great difference in physical geographical conditions is the major factor effected on hydrogeological conditions in coal fields.

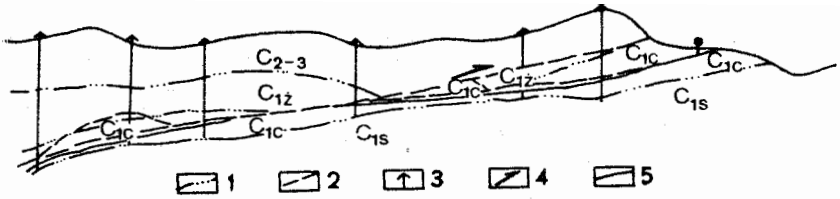


Fig. 3. A diagram of geological cross-section in coal mine in Hunan Province.

1 - boundang of styatum, 2 - fault, 3 - drilling hole, 4- move direction for upper wall of fault, 5 - coal seam

C_{2+3} - Hutian Limestone in middle upper series of Carboniferous Period, weak aquifer

C_{1z} - Zimanqiao Limestone in down series of Carboniferous Period, weak aquifer

C_{1c} - Ceshui Coal Measures in down series of Carboniferous Period

C_{1s} - Shidengzi Limestone in down series of Carboniferous Period.

A surface relief in China is low and flat in south and east, high in North and west. Lot precipitations are in south and east and it is dry in north and west. Coal fields in the South-East part are always rich in water. The coal measures are most coved by soft aquifers in Cainozoic Era and the hydrogeological conditions are generally complicated. The coal fields in the north-west part are poor in water and the overbuden surface are open or loess. Except some area with a river valley, there generally are lacking of soft aquifers in Cainozoic Era. The hydrogeological conditions in the coal fields are fairly simple.

As for Palaeozoic coal fields in North-China, at east part of Taihangshan Mountain, coalseam are most deposited under a water table. During a seam mining, it had to bear a high water pressure from a karst aquifer of a limestone in underlying Ordovician Systems. This will easily occure water burst from floor and cause a mine flooded. Also due to a sand and gravel aquifer with a great depth in upperlying Cainozoic Era, it will occure certain problems of mine shaft sinking. At Shanxi-Shuanxi highland which is in the west part of Taihangshan Mountain, coal seams are in a low depth from the surface and are deposited above the water table of limestone in Ordovician System. There is no sand and gravel aquifer above the seam and no danger of waterconming from limesyone in Ordovician under the seam. Therefore, the hydrogeological conditions are very simple. Only if a mining at a depth, when a water pressure in floor increased at a certain level, it may occure a floor water burst.

As for coal fields with fissure water in Mesozoic Era,

there is a great difference hydrogeological conditions between mines at a river valley are rich in water and have a sufficient water supply. Sometimes it may occur a danger which means surface water or mudy sand may flow into openings of a mine. Mines at a divided line has few water and poor water supply from other places. The surface is favourable for drainage of surface water and underground water. During a coal mining, there is no danger from water, except a consideration for water in mined area.

5. A VARIETY OF HYDROGEOLOGICAL CONDITIONS IS ANOTHER CHARACTERISTIC IN CHINESE COAL FIELDS.

Due to several minerogenetic epoches and coal fields widely spread over, so a palaeogeographic condition, deposition and back ground of architectonic in each coal field at minerogenetic epoch, geological history, coal field structural formation, seam metamorphous grade and diagenetic grade after minerogenetic and the physical geographical conditions are all different. The hydrogeological conditions for each coal field are variety and have its different character.

As for main water-bearing structures in coal mine, some coal fields are in the large artesian basin (Palaeozoic coal fields in North China), some in midium and small artesian basins or artesian declined land (some Palaeozoic coal fields in South China), some in closed fault block and horst or graben (such as somemidium and small coal fields in North-east China and South China), and some under water-bearing nappe structures (such as Zhadong coal field in Hunan province, Shanshonggang coal field in Jilin province).

As for physical geographical conditions, some coal fields are in the dry highland at North-west China, some in the sufficient precipitiation area along the sea at south east part of China, some in the midium rains area at middle of China, and some in all year freezing area. Coal fields are in highland, mountain area or above local erosional basis, some coal fields are open with basis rock and some in the great depth.

As for the mine water inflow, there is a great different in each mine. Some mines have almost no water or have only a small amount of water. Some mines have water inflow over 1000 m^3/h or some coal fields have special amount of water in flow over 10 000 m^3/h. In some mine, one ton of coal production will have to drainage water upto 100 tonnes.

As for water inflow pattern and nature, some coal fields mainly has water inflow through seam floor and some coal fields has inflow from roof. Some coal fields mainly has inflow through faults and some mainly has inflow from rains. Some mainly have inflow from surface water, some mainly have inflow from mined area and some mine mainly has inflow from underground hot water.

From a view of engineering geological issue which has a relation with hydrogeology, some coal field may have sand inrush into mine openings. Mine openings will be seriously deformed and hard to retain. Some mine will have floor heave problems

and even be flooded. Some slop in open pit mine will be easy to failure. Some mine and its area will have a large area karst collapse, and some coal field will seriously danger farm land, village and other surface building. Generally, hydrogeological conditions in Chinese coal fields are a great veriety. As for each kind of coal field, it will need to solve its hydrogeological problem and different exploration method during a exploration coal mining.

6. Hydrogeological features in Chinese coal fields have showen an important on the combined underground water supply and drainage and the utilization of the water.

Underground water is our very important resources. With developments of industry and agriculture, a problem of water resource will be getting serious day by day. How to effectively protect and fully utilize the underground water should be a major project to be solved at present. This issue has been considered by the world, and China should be one of the world.

The north and west part of China is a dry area and locking of underground water resources.Water drainages in mine are increasing the problem of locking of water. So, it has to have a water supply and drainage combination. Even in area mainly with karst water at middle and south east part of China, it has sufficient water, but mine inflow coming from main aquifer which is a main water supply resources for industry and agriculture. At a long period, drainage of underground water table down in a larger coal mine area. Even there is no water in water wells. It occured a lot of problems for industries, agricultures and residints to have water. It will further cause ecology change and break the ecology nalance. Obviously, water supply and drainage combination is the way at present. Many mines have a large amount of water drainage, with a scale and depth of mining increasing, mine water drainage will be increased. For examples, there is a water drainage over 864 000 m^3/day in a mine area at Jiaozuo. Meitanba Mine at Hunan has a coal production only 900 000 ton/year, but a water drainage upto 180000 m^3/day. During a coal mining, water can pump from underground to surface and this will provide a economic first step to utilize the water. Utilization of underground water can greatly increase the mine economic efficiency and improve the mine environmental protection. A effective combination of underground water mining and mine water drainage engineering will reduce mine water drainage and relieve coal resources from a danger of water. All those will have a great significance. In Fengfeng, Zibe, Weinan, Meitanba and Jiaozuo Mines, water supply and drainage combination and water utilization has been conducted. A primary results have been obtained and shown a prospective future.

7. HYDROGEOLOGICAL CONDITION IN CHINESE COAL FIELDS HAVE OBVIOUS LOCAL FEATURES.

As mentioned above, through basic factors to restructe hydrogeological conditions in Chinese coal fields, it caused a law for local changes and divided areas based hydrogeological conditions. A summary is as in table 1.

ition

Type of hydrogeological condition in deposition	Main with void water	karst	water
Mame of area		a	South China
Main minerogentis epoch	Tertiary System	s System	Mainly in Permian System
Location of area	At east of Heluanshan and Hendanshan, in midium and small coal basin	n-Qinling uth of Structure Helan-Liu- e	At south of Kunlun-Qinling Structure Zone and east of Chuantian Old Land
Hydrogeological features of main deposition in each area	Poor in water bearing small mine inflow. In coal mining, the engineering geological conditions are fainly complicated with sand inrush, opening deformation, slop failure, underground transportation difficult. only a few coal fields hydrogeological condition are complicated	e limestone em, then in em. Hydro- ons quiet bearing y large, ine water -heave-wa- y, some specially, of Taihan of Taihan aphy is rground lying, so, ditions ow mine deep mine. th China, e under fer, en- s are com-	Mackou Limestone and Changxing Limestone are the main water recharge source of coal mines. Due to complication of structure, recharge areas are smaller, but with a large rains recharged to underground water, so mine water are fairly large. Karst very develop in shallow part of limestones, with underground rivers. In deep part, hydrogeological conditions are simpler. After mine water drainage, surface ground are easy to collapse and make danger to the surface buildings.
Hydrogeological condition of water supply	Sand or gravel aquifer; Karst water.	dion should f w	Generally, no problem in water supply within mine area.