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Research of Cycle and Migration Mechanism of Deeper Karst Geothermal Water in Pingdingshan Mine Area

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Abstract Based on analyzing groundwater level dynamics, chemical component and ground temperature distribution of deeper geothermal water in Pingdingshan mine area, water cycle mechanism of Cambrian karst geothermal water is discussed systematically. The results include that surface and concealed Cambrian karst is supplied by precipitation in west of mine; and that ground water transports from trend of Cambria karst to north and the depth, at the same time, flows to east-south, and that the biggest depth of cycle is in axial part of Likou, and that karst water transporting from supply area to No.8 mine need over 60 years, which shows that conditions of water cycle is bad in No.8 mine.
Keywords deeper karst geothermal water, groundwater level dynamics, chemical component, geothermal gradient, water cycle mechanism

Introduction

Pingdingshan coal mine is big mine in china. The limestone aquifer in Cambrian system is one of principal Source of inrush water of mine, and it adds mining difficulties that inrush water of mines makes temperature of working face going up. So, it is important to solve the problem of groundwater cycle and migrate in limestone aquifer of Cambrian system. Other studies have researched limestone aquifer of Cambrian system in one way (Zhang et al. 2000; Zhang et al. 2010), but there is no research about water cycle and migration mechanism in many aspects. In the paper, groundwater level dynamics, ground temperature and chemical component are applied to discuss cycle and migration mechanism of deeper karst geothermal water in Pingdingshan mine area.

General situation of Pingdingshan coal mine

Pingdingshan coal mine lies in south of north China plain and is closed in dropping faults. The distributions of faults are dominant and folds are subsidiary in this geological structure. High angle normal faults in NWW play a control role in structure of mine and axial part of Likou is main structure in the coal mine (fig. 1).

There are three karster aquifers in Pingdingshan coal mine, which are limestone Cambrian and limestone carboniferous Taiyuan and marlite neogene. Outcrops of limestone Cambrian only appear in east-south of mine and karst fissures develop in shallowly and outcropping region. The Limestone carboniferous Taiyuan is almost covered by quaternary and coal stratum and the development of karst fissures become weak from shallow to depth. Marlite neogene mainly appears in east-south of mine, looks like a belt along with both sides of up Zhan-river and its thickness is most in No.5 mine and No.7 mine. There is abundant karst fissures and rich water in aquifer of marlite neogene, which has discordant contact with karst aquifer of Cambrian, carboniferous taiyuan and sandstone aquifer of Permian. Especially, shallow buried depth causes it to get replenishment easily from atmospheric water and surface water, which also links up hydraulic connection of new and old aquifers in some region.

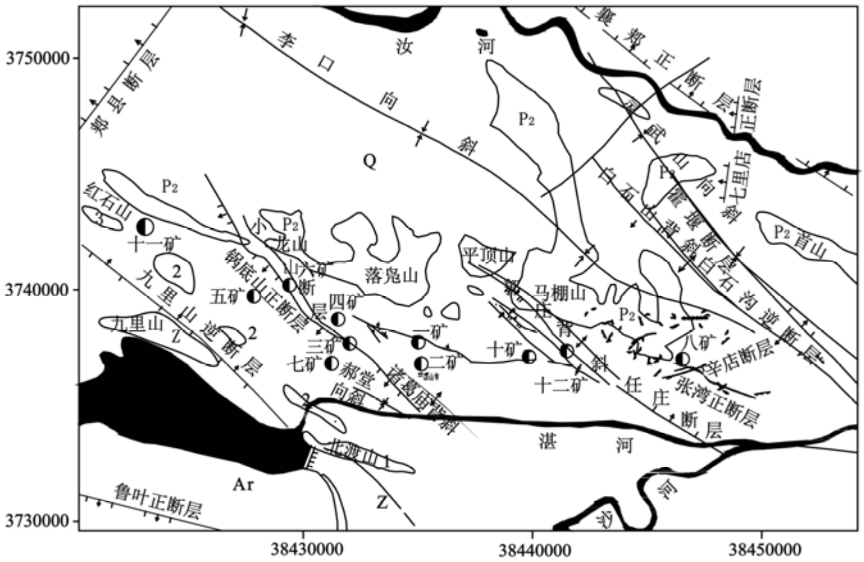

Fig. 1 *Structure map of Pingdingshan mine area*

Discussion and results

Dynamics characteristics of groundwater level

According to hydraulic conductivity and resisting property, characteristic of hydrogeology and supplement-flow-drain condition of ground water, hydrogeology unit is divided into east and west both units by Guodishan fault.

The west of guodishan fault is west hydrogeology unit and the other one is east unit. West region includes No.7, 9 and 5 coal mine and the outcrop distribution of middle and up limestone Cambrian have dominant degree in this unit which is main supplement region of pingdingshan coal mine because of getting directly supplement atmospheric water. Some results can be concluded from figure 2 that normal proportional relationship in found among inrush quantity of mine, atmospheric water and north main canal, and that inrush quantity enlarge in rainy season or the days of recharge water and drop in dry season or the days stopping.

East region has No. 1, 2, 3, 4, 6, 8, 10 and 12 mine. In this unit, middle and up Cambrian is buried with more depth and the south of coal outcrop is directly covered by quaternary and the north of supplement condition is weaker than the west unit because of under coal layers of carboniferous and Permian. It can be concluded from fig. 3 that there are no significant correlation between inrush mine and atmospheric water, and that water level is dropping since 1986 due to the effect of mining and draining water over a long period.

The change of karst water level can be discovered from contour lines in fig. 4. Water level of south of No. 11, 5 and 7 mine is high in outcrop of Cambrian and level deep slowly along with north and east-south. The whole water tendency flows from west to east and from north to south. Because of quantity difference and formation of discharge, there are depression cones in some regions.

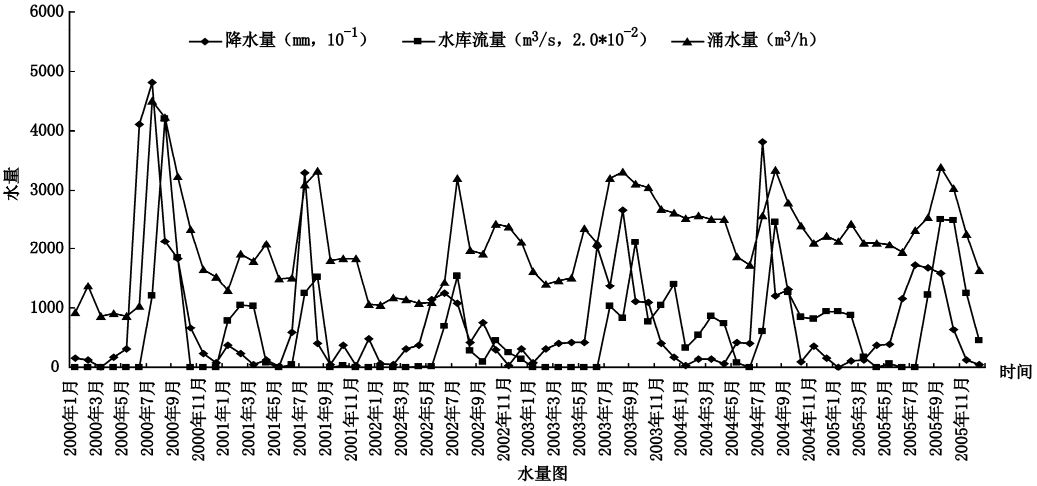

Fig. 2 *Relation of atmospheric water, Zhan-river recharge and No.7 mine inrush*

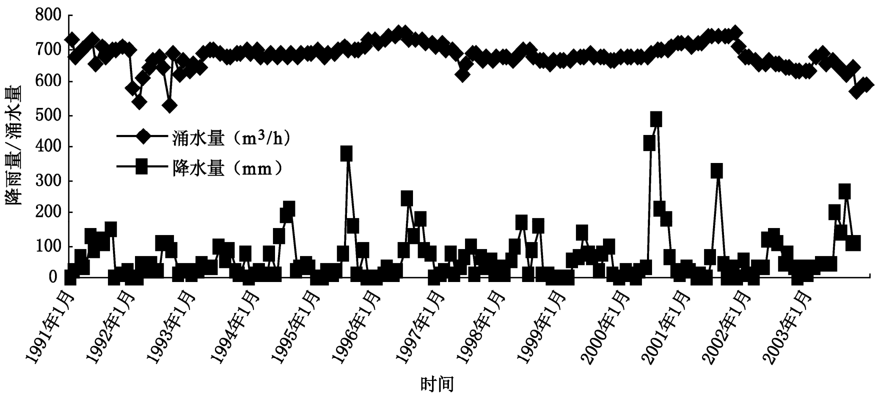

Fig. 3 *Relation of atmospheric water and No. 8 mine inrush*

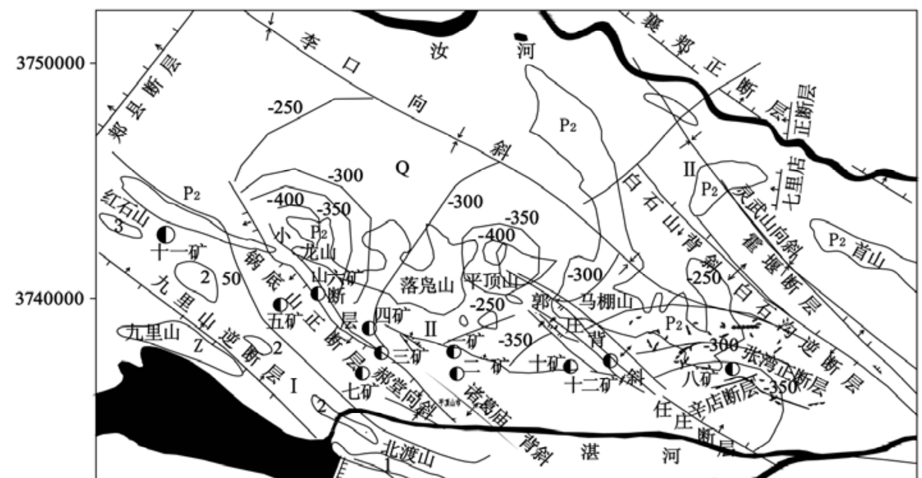

Fig. 4 *Isoline map of Cambrian karst groundwater level in mine area*

The change of karst water level can be discovered from contour lines in fig. 4. Water level of south of No. 11, 5 and 7 mine is high in outcrop of Cambrian and level deep slowly along with north and east-south. The whole water tendency flows from west to east and from north to south. Because of quantity difference and formation of discharge, there are depression cones in some regions.

Characteristics of geothermal field

Geothermal gradient is highest in No. 8 mine with most development faults and fissures, and the average value is over 3.7 ℃/100 m. Especially, to Xindian fault, the east developments are more than the west. So the east geothermal gradient (4.0~4.66 ℃/100 m) exceeds obviously the west (3.7~4.0 ℃/100 m). The region of No. 6, 4 and the south of No. 3 mine develop a multitude of small-sized faults intersected with Guodishan fault, which cause higher geothermal gradient (3.5~3.7 ℃/100 m). The geothermal gradient of No. 10 and 12 mine are among 3.5~3.7 ℃/100 m because of richer faults and small-sized folds (Wang et al.2001).

Geothermal gradient of Luofu Mountain with poor development fracture structure is less than 3.0 ℃/100 m and the north of No. 4 mine belongs to lower gradient area which figure only reaches to 2.60 ℃/100 m. However, to the axial of Likou, geothermal gradient increases slowly from west to east (Liu et at. 2004).

Hydrochemical characteristics

Basic ions of Cambrian water in this region are HCO_3^-, Ca^{2+} according to 28 water samples, and the main type of water quality is Ca-HCO_3.

From the west of No.11 mine to the east of No. 8 mine, the evolution tendency of water quality type is HCO_3-Ca→HCO_3-Mg→HCO_3·SO_4-Na·Ca, total dissolved solid and the contents of SiO_2, CO_2, HCO_3^-, Cl^- increase slowly. When total dissolved solid is less than 0.65 g/L in west of No. 8 mine, the contents of Ca^{2+}, Mg^{2+} arise. However, if total dissolved solid is more than 0.65 g/L, the contents of Ca^{2+}, Mg^{2+} drop and Na^+ increase. This vary rule is results of water ions physical chemistry balance.

Potenzialwert of oxidation-reduction is between -333～-374 mV (table 1) and the groundwater environment is weak oxidation-reduction according to Eh value. Combined with fig.1, it can be found that the Eh value decreases from west to east, which indicates environment varies from weak oxidation to weak reduction.

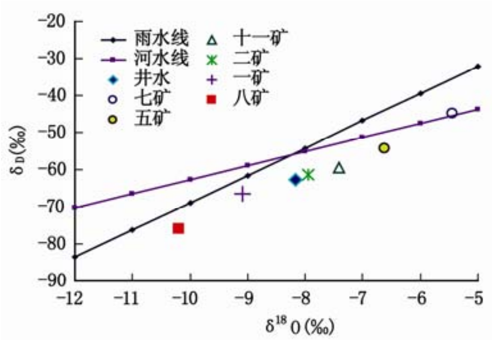

Fig. 5 *Curve of precipitation , δD and $\delta^{18}O$ of karst*

Table 1 *Eh size of karst in Pingdingshan mine area*

Coal mine	11	5	7	2	8	Average
Eh（MV）	-374	-356	-333	-369	-374	-361

Isotopes characteristics

The tests of isotopes in Pingdingshan coal mine mainly include δD, $\delta^{18}O$ and ^3H. Fig. 5 is the relation of precipitation δD and $\delta^{18}O$ of karst. Surface water come from atmospheric rainfall of different periods which can be proved by the cross dot between surface and atmospheric water line. In fact the formation of Baiguishan reservoir is collected atmospheric water of different periods.

It can be deduced from the relation of stable isotope dots and surface water line that No. 7, 11 and 5 mine accept supplements directly from atmospheric water and surfer water and the recharge mount of No.7 mine is bigger than others. Under the condition of drainage karst water, No.5 mine get surfer supplement via from No.7 mine. Karst water of No.2, 1 and 8 mine come of atmospheric water, but it move a long distance. There is no significant "oxygen shifting", it is deduced that the temperature of thermal groundwater in Pingdingshan coal mine is in the range of middle-low and thermal groundwater is not result of deep crust mixed heat resource but of deeper circulation of atmospheric water and surface water.

^3H activities of No. 7, 5 and 11 mine are 22.20 TU, 16.72 TU, 16.10 TU in west Guodishan fault, and ^3H activity of No.5 mine is higher than No. 11 mine but lower than No.7 mine, which is caused by No. 7 getting Zhan-rive supplement, No. 11 rainwater supplement and No.5 mixing supplement of surface water and rainwater. ^3H activities of No. 1 and 2 mine are 14.65TU, 14.48TU, which are higher due to supplement of west Guodishan fault in between Zhan-river and Sha-river. ^3H activity of No. 8 mine is less than 1.7TU which is much lower than No. 1 and 2 mine. It indicates that hydraulic connection is faint among No. 8,1 and 2 mine which may be caused by many compress shear faults between No. 10 mine with No 8 mine separating supplement from No. 1 and No. 2 to No. 8 and 10 mine. According to ^3H activity of No. 8 mine, karst water is more than 60 years old which indicates that permeability and discharge of Cambrian aquifer is poor, and water alternate recycle is bad, and supplement resource is far away from No. 8 mine (Pang et al. 1990).

Conclusions

Karst thermal groundwater achieve supplement in No. 11 mine of west hydrogeology unit, and flow to North and depth through strata inclination and to east-south direction simultaneously. Thermal groundwater is not result of deep crust mixed heat resource but of deeper circulation of atmospheric water and surface water. The deepest water recycle is the axial of Likou in which thermal water is heated and then flow to No. 8 mine due to resistance of Huoyan fault. Because compress-shear structure of south and abundant structures and fissures in No. 8 mine exist, there is formation of rich water and geothermal anomaly. Karst water of No. 8 mine is over 60 years old and the supplement of No. 1 and 2 mine come from Guodishan fault.

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