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Hydrogeological Characteristics of the Large-scale Coal Base of Qinghai-Qilian, China

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Abstract The large-scale coal base of Qilian in Qinghai province, located in the permafrost regions of Qilian Mountain hinterlands of Tibetan Plateau, has unique hydrogeological conditions and fragile ecological environments. In the area, there are four types of groundwater: the groundwater of the erosion thawing zone, the groundwater of the structure thawing zone, the groundwater above the frozen layer, and the groundwater under the frozen layer. The common chemical types of the groundwater above the frozen layer are $Ca{\cdot}Mg\text{-}HCO_3{\cdot}SO_4$ and $Ca{\cdot}Na\text{-}HCO_3{\cdot}SO_4$, the TDS is often lower than 0.3 g/L. The chemical type of the structural fractured water is mainly $Na\text{-}HCO_3$, the TDS is higher than 0.5 g/L. Thermal springs are the types of $Na\text{-}HCO_3$ with the values of TDS higher than 1 g/L.
Keywords coal base, groundwater, thawing zone

Introduction

Qilian large-scale coal mine base (QLCMB) is one of key energy base constructed in Qinghai province (fig. 1). Mining area of Jiangcang, which is located in permafrost region in Qilian mountain area in Tibetan Plateau, is one of coal mines of QLCMB that has altitude between 2800 m to 4200 m. Groundwater occurrence, circulation and evolution in this area are controlled by distribution of permafrost and geological structure. Alpine meadow ecosystem in this area has characteristics of sensitive, fragile, easy to destruction and hard to recovery. The permafrost environment, alpine meadow ecosystem and balance of groundwater system have been seriously influenced by irrational exploitation and utilization. The main hydrogeological and environmental geological problems are water resource shortage, water and soil pollution, destruction of frozen soil environment, deterioration of alpine meadow ecosystem and threaten of water bursting hazard. Hence, hydrogeological and environmental geological investigation in mining area could provide scientific basis to groundwater utilization, aquifer system protection and eco-system reparation.

Hydrogeologic settings

Distribution of permafrost and thawing zone

Permafrost in this area is patchy distributed with thickness between 10 m to 60 m. Seasonal melting thickness is about 2 m. The middle to large scale of the thawing zones in this area are main groundwater occurrence regions. The main types of the thawing zones are: 1) erosion thawing zone (including the river thawing zone and the lake thawing zone), 2) structure thawing zone, 3) weathering thawing zone (adret thawing zone).

Main aquifers

Due to compression between Tuolai Mountain from north and Datong Mountain from south, Muli-Jiangcang basin area was made a pair of Triassic basement depression basins. The main aquifers in this area are Quaternary porous aquifer (strong rich in water), Triassic (strong rich in water), Jurassic and Tertiary sandstone fractural aquifer and Precambrian marble karst aquifer (strong rich in water).

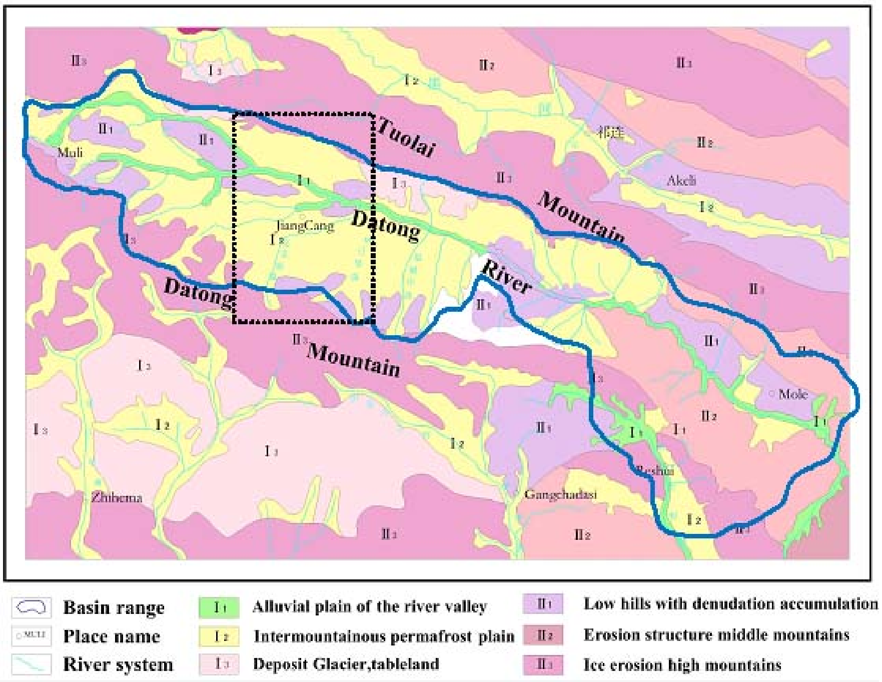

***Fig. 1** Geomorphologic map of Qilian large-scale coal mine base*

Major groundwater storage construction

Fault structure in the NWW direction in the study area is the enrichment zone of sandstone fissure water, with lots of thermal spring. There are four types of storage structures: the Triassic sandstone - Precambrian metamorphic rocks - structural fault storage, Jurassic sandstone - Tertiary mudstone - tectonic fault storage, Triassic sandstone - Tertiary mudstone - tectonic fault storage and Marble - Triassic sandstone - fault storage structure.

The overlapping relationship between coal bed and aquifer

There are two tapes of overlapping relationship: mode of inverse superposition and mode of anterograde superposition (fig. 2). In the former type, coal-bearing strata is on the upstream of the aquifer system, and coal mining destroy the aquifer system directly. In the later type, coal-bearing strata is in the downstream of the aquifer system, coal mining is threatened by water bursting hazard.

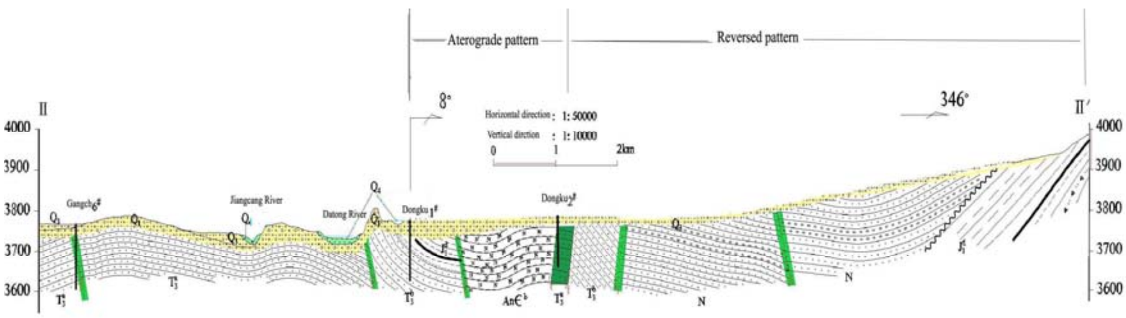

***Fig. 2** The overlapping relationship between coal bed and aquifer*

Types of groundwater

Groundwater of Erosion talik: This type of water is distributed mainly in the river thawing zones and is supplied by river and precipitation. It is the main target area for water researching. Groundwater of Structural thawing zones: This type of water is distributed mainly in the structural thawing zones. It is often outcropping by big spring along structural, which can also be regard as a target. The water upon the permafrost: This type of water is distributed mainly upon the permafrost (impervious base) and has a thickness of less than 2 meters. Melting water and precipitation are the suppliers. It has a significant seasonal dynamic characteristic: in summer, it appears as spring group in the junction of platform and valley; but in the winter, it freezed, so it is hard to utilize. The water under the permafrost: This type of water is distributed mainly in the center of the basin and occurs in the sandstone fissure. It is under weak pressure and has rare fluxes. Decline springs in the valley: This type of water is distributed mainly in the foot of a mountain. It was supplied by water upon the permafrost and has a significant seasonal dynamic characteristic. This type of water is a major supplier of surface water. Spring in the structural thawing zones: This type of water is distributed mainly along structure and has a great amount of flow. It is supplied by river and precipitation, and has stable dynamic. Thermal spring: This type of water is distributed mainly near the tectonic belt and has a high temperature and cycle depth.

Groundwater hydrochemistry and isotope characteristics

Suprapermafrost water (valley depression spring): 1) TDS of suprapermafrost water was generally less than 0.3 g/L, and pH value was greater than 7, which showed weakly alkaline. Besides, hydrochemical types were mainly $Ca{\cdot}Mg\text{-}HCO_3{\cdot}SO_4$ and $Ca{\cdot}Na\text{-}HCO_3{\cdot}SO_4$. 2) Tectonic crack water (fault spring): TDS of the tectonic crack water was generally greater than 0.5g/L, and pH value was also greater than 7, which showed weakly alkaline. Its hydro-chemical type was mainly $Na\text{-}HCO_3$. 3) Deep hot springs: its TDS was generally greater than 1.0 g/L, and its hydro-chemical type was mainly $Na\text{-}HCO_3$. 4) The river: TDS of it was generally less than 0.3 g/L, and the hydro-chemical type was mainly $Ca{\cdot}Na\text{-}SO_4{\cdot}HCO_3$ and $Na{\cdot}Ca\text{-}SO_4{\cdot}HCO_3$. 5) Snow water: TDS of snow water existed big difference of diverse samples in different areas, but its hydro-chemical type was mainly $Na\text{-}SO_4$.

Environmental isotope showed that groundwater resulted from atmospheric precipitation. The surface water had an evident oxygen drift phenomenon (fig. 3). Suprapermafrost water distributed near the local precipitation line, resulted from the modern precipitation. The bedrock fissure water formed a relatively long time. The isotope characteristic value was low, deviating from the local precipitation line. The isotope characteristic value of deep hot springs was lowest, deviating from the local precipitation line. It also formed in the ancient time.

Circulation patterns

There are three main kinds of circulation way. First, Suprapermafrost resulted from melt water and precipitation water, formed depression spring at valleys and river terraces by shallow cycle, then drained to the river erosion taliks, and finally formed valley quaternary pore water. Second, bedrock fissure water resulted from melt water and atmospheric precipitation formed fault spring at the tectonic split fault by shallow cycle. Third, bedrock fissure water resulted from melt water and atmospheric precipitation formed geothermal water by deep circulation way, and drained the ground at the split in the form of hot spring.

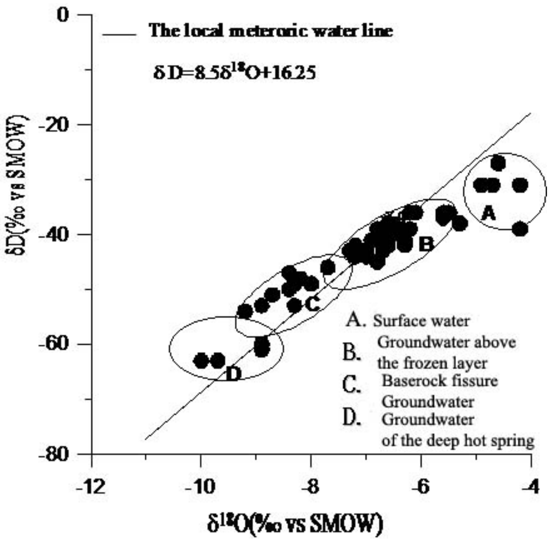

Fig. 3 *Relationship between δ^2H and δ^2O in groundwater*

Summary

The basic characteristics of the hydrogeological structure, the occurrence regularity and cycle way of the groundwater and the thermal springs' relationship between the coal seam and aquifer have been ascertained in this investigation, which can be used for utilization of groundwater in energy base, protection of aquifer system and restoration of the ecological environment as well as a significant basis for scientific decision-making.

Acknowledgements

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