Research on Hydrogeological Disaster Risk Prediction of Dachang Gold Deposit in Qinghai Province

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Abstract: Aiming at the problem of low prediction accuracy of traditional methods, this paper proposes a research on hydrogeological disaster risk prediction of Dachang Gold Deposit in Qinghai Province. After selecting the five predictors -- geological structure characteristics, meteorological characteristics, groundwater system, rock development degree and stratigraphic characteristics, the prediction index system for hydrogeological disaster risks was established by the predictors; then the analytic hierarchy process was used to determine the weight of the predictor, and the fuzzy information comprehensive predictive function was used to perform fuzzy calculation and normalization on the predictors. Finally, the fuzzy method was used to solve the function and then obtain the result of hydrogeological disaster risk prediction, thereby realizing the hydrogeological disaster risk prediction of Dachang Gold Deposit. Relevant experiments have proved that this method has high prediction accuracy.

1. Introduction

The Dachang Gold Deposit area in Qinghai Province belongs to underdeveloped water system. Most rivers there are seasonal ones, and north-south rivers can only be seen in the north and east of the mining area. The rivers dry up during the dry season and the flow rate is 2~14m³/s in the rainy season. Their altitudes are 1176-1189m and can be regarded as the lowest erosion surface of the mining area. There are reservoirs and man-made ponds near the mining area (<5km), which can be used as industrial water sources; and there is a well in the middle of the mining area, which can be used as a source of living water. No springs have been found in the mining area. The surface water is mainly seasonal mountain rivers and the main source is atmospheric precipitation. The groundwater in the mining area is abundant and is the main water used for local planting. The underground phreatic surface is about 1174.1~1206.0m, and the basic type of groundwater is bedrock fissure phreatic water. The main replenishment source of groundwater in the mining area is atmospheric precipitation, which infiltrates vertically through the weathered fissures of the bedrock to replenish the underlying bedrock aquifer. Groundwater generally migrates from south to north, and flows laterally underground through fissures; and some groundwater is excreted in a vertical manner through surface evaporation and plant transpiration, and then returns to the atmosphere. The geomorphology of the mining area is relatively flat, which is not conducive to natural drainage, and the structure is moderately developed. The rock of the deposit is of medium quality, and the rocks are mainly metamorphic argillaceous rock, slate, phyllite, followed by metamorphic conglomerate, silicon-ferroic rock, meta-andesite and various veins. They are hard rock with medium stability, and it is determined that the deposit belongs to massive rock type, with medium engineering geology. The main problem is that in the future, the rock will be affected by groundwater during exploration and that its strength will decrease; in particular, the weak zones such as fracture zones in the mining area may cause hydrogeological problems [1]. According to preliminary surveys of field geology, there are no landslides and mudslides, and no surface subsidence in the mining area, but there are a large number of old caves and open mining points in the mining area, which are likely to cause surface subsidence. The large amount of waste rock generated in the process of exploratory tunneling may cause hydrogeological disasters under severe conditions, which should be given great attention to in the future exploration process. Therefore, it is necessary to carry out hydrogeological disaster risk prediction for Dachang Gold Deposit in Qinghai Province. Traditional methods have poor prediction efficiency and effect, and cannot meet the related requirements for Dachang Gold Deposit which has a complex geological structure. In this context, the research on hydrogeological disaster risk prediction proposed in this article can provide safety guarantee for the later mining there.

2. Hydrogeological Disaster Risk Prediction Method of Dachang Gold Deposit in Qinghai Province

Dachang Gold Deposit is located in the northeast of Dachang City, Qinghai Province, and it is an important gold metallogenic belt in Qinghai Province. The altitude of the mining area is generally 1200-1250m above sea level, and the terrain is relatively flat; the altitude of a few low-lying places can be to 1150m, and the terrain height difference is generally 0-20m; in some places, the terrain height difference is as high as 20-80m [2]. The tectonic line of the mining area is northeastward and has experienced multiple periods of tectonic movement. In the early period, regional tectonic movement led to the formation of a series of folds and faults with a tectonic line trending mainly northeast; in the later period, a nearly north-south superimposed compression was formed due to the emplacement of Baili gneissic granite, which was mainly manifested as a series of closed folds and their associated faults, fissures and cleavages. The following picture shows the geological structure of the Dachang Gold Deposit in Qinghai.

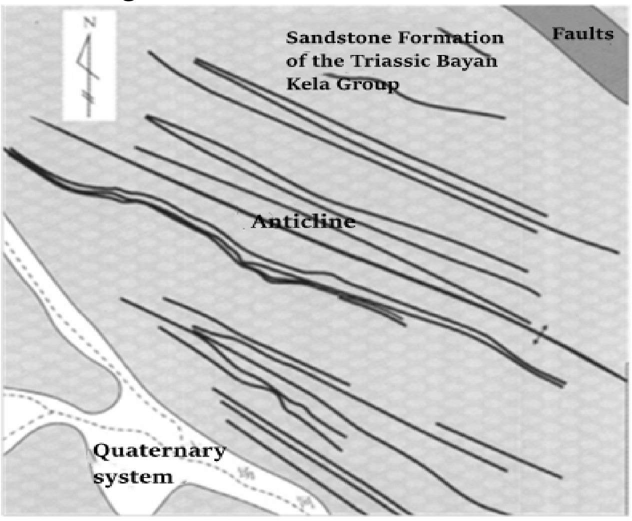

Fig.1 Geological Structure of Dachang Gold Deposit in Qinghai Province

In this paper, the method for hydrogeological disaster risk prediction was designed according to the geological characteristics of Dachang Gold Deposit in Qinghai. First of all, a prediction index system for hydrogeological disaster risks was formed on the basis of the geological structure characteristics, meteorological characteristics, groundwater system, rock development degree and stratigraphic characteristics there. Then, the analytic hierarchy process (AHP) was used to determine the weight value of the predictor, and the fuzzy calculation was performed on the weight set by establishing a fuzzy information comprehensive prediction function. Finally, the function was solved by the fuzzy method to complete the hydrogeological disaster risk prediction of Dachang Gold Deposit in Qinghai Province.

2.1 Establish the Prediction Index System for Hydrogeological Disaster Risks

The prediction index system for hydrogeological disaster risks is composed of multiple predictors, and the predictors are the factors that affect the occurrence of hydrogeological disasters. Due to the uncertainty and complexity of the influencing factors of hydrogeological disasters, the hydrogeological disaster risk prediction of Dachang Gold Deposit is faced with various difficulties. Therefore, the establishment of a reasonably structured and well-defined prediction index system for hydrogeological disaster risks plays an important role in the final prediction results of Dachang

Gold Deposit there [3]. Combined with the geological characteristics of Dachang Gold Deposit, a prediction index system for hydrogeological disaster risks was established in this paper, and the selected predictors include geological structure characteristics, meteorological characteristics, groundwater system, rock development degree, and stratigraphic characteristics. Based on the geological survey data there, analysis was given to every predictor. (1) Geological structure characteristics: The fold structure of the mining area is mainly distributed by the strata, which is manifested by the development of a closed compound inverted oblique in the east and belongs to a closed synovial inverted fold. The syncline axis runs northeast and slopes southeast with an inclination angle of about 75°. The hub is heading northeast, and the inclination angle is close to horizontal. The formations on the two wings are basically the same, leaning south-east, with dip angles ranging from 60° to 85°. The fault structure is relatively developed, mainly with north-east, north-west, north-south and east-west faults. Among them, the NE-trending group is the most developed and is the most important ore-controlling and ore-hosting structure in this area [4]. (2) Meteorological characteristics: The mining area presents a temperate climate, with an average annual temperature of about 22°C. The year is divided into three seasons: April~August is the cool season, September ~November is the hot season, and November~March is the snow season. July is the hottest month, with temperatures as high as 32°C. December has the lowest temperature, with an average annual rainfall about 800mm. The rainfall is mainly concentrated in the rainy season from May to July. The rainfall in the dry season only accounts for 1-10% of the annual rainfall, and the rainfall from September to December is only about 6mm. The annual average evaporation is 1371.6mL, which is greater than the precipitation. (3) Groundwater system: The groundwater structure in the mining area is relatively complete, with sufficient water content in the aquifer, and the thickness of the floor and the aquifer are 59m and 108m, respectively. The table below shows the phreatic surface height of the hydrological observation of Dachang Gold Deposit in Qinghai Province.

Table 1 the Phreatic Surface Height for Hydrological Observation of Dachang Gold Deposit

Drilling No.	Coordinate			Stable water level of final drilling/m	Elevation of phreatic surface/m
	X	Y	H/m		
001	UTM7978278	36K0188519	1204	14.30	1189.70
002	UTM7978303	36K0188517	1204	19.00	1185.00
003	UTM7977068	36K0187180	1210	26.00	1184.00
004	UTM7977065	36K0187323	1206	17.00	1189.00
005	UTM7978050	36K0187932	1206	20.00	1186.00
006	UTM7978043	36K0187967	1223	21.20	1201.80
007	UTM7978030	36K0187945	1216	29.30	1186.70
008	UTM7978028	36K0187928	1214	17.80	1196.20
009	UTM7978048	36K0187869	1221	24.50	1196.50
010	UTM7978048	36K0187831	1219	13.00	1206.00

According to the survey data of the groundwater system in the mining area, the average groundwater level of the mining area is 18.6m, and the average phreatic surface height is 1189.50. (4) Rock development degree: The mining area is mainly composed of meta-argillaceous rock, slate, phyllite assemblage, sandstone, glutenite, stripped silicon-ferric rock, meta-andesite, meta-basalt, meta-tuff, and various intrusive rock veins among them. Rock veins include gabbro veins, diabase veins, diabase porphyrite veins, diorite veins, granite porphyry veins, quartz porphyry veins, etc. They are mainly layered and massive, which are hard rock, with a blocky structure as a whole and with good rock integrity. (5) Stratigraphic characteristics: The stratum in the mining area belongs to Sandstone Formation of the Triassic Bayan Kela Group, and the core stratum is the upper sedimentary rock series of the Shamwa System. From the core to the two wings, the lithological assemblages are successively the assemblages of blastopsammite and slate phyllite, the assemblage of blastopsephitic boulder conglomerate, the assemblage of stripped silicon-ferric rocks, and the assemblage of blastopsammite and slate phyllite. The stratum on the two outer wings is mainly Bulawayo Greenstone System.

2.2 Determine the Weights of Predictors

In the risk prediction system for hydrogeological disasters, each predictor has a different degree of influences on the hydrogeological disasters of Dachang Gold Deposit in Qinghai Province. In order to reflect their respective importance, each predictor needs to be assigned a corresponding weight value [5]. There are many methods to determine the weight value of each predictor in the hydrogeological disaster risk prediction. Commonly used methods include data statistics, fuzzy calculation, analytic hierarchy process (AHP), and data statistics, etc. Among them, the determination process of data statistics method, fuzzy calculation method and data statistics method is complicated, and the weight value obtained by them does not match the predictive factor, which will affect the accuracy of the result of the final hydrogeological disaster risk prediction. Therefore, AHP was used in this paper to determine the weight value of the predictor about Dachang Gold Deposit in Qinghai. Assign reasonable weights to the predictors, and the set of weights is:

$$H=\{\mathrm{h}_1,\ \mathrm{h}_2,\ ...,\ \mathrm{h}_m\}\ (1)$$

In the formula (1), h represents the predictors, and h_1 represents the predictors which has been assigned a weight value. The calculation formula of weight value is:

$$\sum h_{1,2,...,m}=1\ (2)$$

Use formula (2) to calculate the weights of the predictors proposed above, the weight set of the hydrogeological disaster risk predictors of Dachang Gold Deposit is obtained. The following table shows the weights of hydrogeological disaster predictors in Dachang Gold Deposit in Qinghai Province.

Table 2 Hydrogeological Disaster Predictor Weights of Dachang Gold Deposit

Predictor	First-level weight	Second-level weight	Total weight
Geological structure characteristics	0.1865	0.1536	0.0144
Meteorological characteristics	0.1654	0.2135	0.0312
Groundwater system	0.2361	0.1864	0.0154
Rock development degree	0.1523	0.2315	0.0464
Stratigraphic characteristics	0.1485	0.1464	0.0314

2.3 Establish a Comprehensive Prediction Function for Fuzzy Information

After determining the weights of the predictors, it is necessary to perform fuzzy calculation and normalization on the set H to obtain the hydrogeological disaster risk prediction results of Dachang Gold Deposit. Because the hydrogeological disaster risk prediction is an ambiguous problem, the method of establishing a fuzzy information comprehensive prediction function is used to perform fuzzy calculation and normalization of the predictors. The main feature of the fuzzy information comprehensive prediction function is that the information itself provides a fuzzy basis, and thus the corresponding inevitability law can be used for fuzzy recognition with reference to the predictor. The fuzzy information comprehensive prediction function is used to quantify the predictors, so as to realize the hydrogeological disaster risk prediction of Dachang Gold Deposit in Qinghai Province. The fuzzy information comprehensive prediction function is as follows:

$$f=\sum h\times H\ (3)$$

According to the principle of maximum unit membership, the value obtained by formula (3) is the hydrogeological disaster risk level of Dachang Gold Deposit.

2.4 Realize Hydrogeological Disaster Risk Prediction

After the fuzzy information comprehensive prediction function is established, it is necessary to establish a hydrogeological disaster risk prediction corpus of Qinghai Dachang Gold Deposit, and then output the prediction result similar to the prediction function according to the fuzzy information comprehensive prediction function. The establishment of the prediction corpus needs to give a summary prediction result of the hydrogeological disaster risks in the target area according to certain risk judgment rules. Combining the weight value of the predictor, the author established the hydrogeological disaster risk prediction corpus of Dachang Gold Deposit, as shown below:

$$V=\left(v_1,v_2,...,v_n\right)\ (2)$$

In formula (2), V represents the set of predictor corpus, v_1 represents the extremely high risk level of hydrogeological disasters in Dachang Gold Deposit, v_2 represents the high risk level, ..., and v_n represents the lowest risk level. Fuzzy analytic hierarchy process (FAHP) is used to solve the fuzzy information comprehensive prediction function. it is an intelligent function solving method, which has the advantages of strong versatility and simple coding. FAHP is more advantageous for solving fuzzy information comprehensive prediction function, and this method can automatically select the prediction description that are similar to the function result after solving the function. After solving the fuzzy information comprehensive prediction function by FAHP, it is concluded that the hydrogeological disaster risk of Dachang Gold Mine in Qinghai Province belongs to the second level, indicating that servious hydrogeological disasters will occur soon. In this way, the hydrogeological disaster risk prediction of Dachang Gold Deposit is realized.

3. Experiment

The author designed a hydrogeological disaster risk prediction method based on the geological characteristics of Dachang Gold Deposit in Qinghai Province. In order to prove that this method can better meet the hydrogeological disaster risk prediction requirements in that area, a set of comparative experiments was designed and the method was compared with traditional prediction methods. In this experiment, seven mining areas were selected as the targets of hydrogeological disaster risk prediction. Two methods were adopted to predict the hydrogeological disasters of the seven mining areas, and the geological structure characteristics, meteorological characteristics, groundwater system, rock development degree, and stratigraphic characteristics were selected as predictors. Formula (2) was used to calculate the weight value of each predictor, and then formula (3) was used to calculate the hydrogeological disaster risk levels of the seven mining areas. The following figure shows the comparison of the prediction accuracy of the two methods.

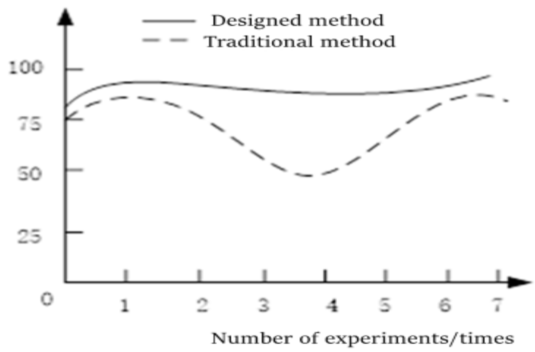

Fig.2 Comparison of Prediction Accuracy of the Two Methods

As can be seen from the figure above, the average prediction accuracy of the method designed this paper is 87%, while that of the traditional method is only 67%, which is far lower than the former one. It shows that the designed method has high prediction accuracy and can meet the need of hydrogeological disaster risk prediction for Dachang Gold Deposit in Qinghai Province.

4. Conclusion

Hydrogeological disaster risk prediction is an important means to ensure the safety of the construction site in the mining area, and it plays an important role in the stable and smooth mining of the mining area. Based on the geological characteristics of Dachang Gold Deposit in Qinghai Province, a hydrogeological disaster risk prediction method was designed in this paper. This method has high prediction accuracy and can achieve good prediction results.

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