

Combined application of hydrogeological survey and comprehensive geophysical exploration for groundwater prospecting in granite areas, south Jiangxi

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SUMMARY

Villages in the southern part of Jiangxi Province are facing a severe shortage of safe drinking water. To address this issue, groundwater exploration was conducted in 20 water-deficient villages in southern Jiangxi Province, supported by the Drinking Water Safety Project of China Geological Survey Bureau. This paper presents the findings of groundwater exploration in four locations in Ningdu County, where there is a widespread distribution of granite in the areas. The study introduces the hydrogeological information of each surveyed area, which served as the basis for selecting the exploration areas and designing the survey grid. Suitable geophysical methods were chosen, and field work configuration was optimized based on theoretical calculations. Once the data were collected, they underwent processing and interpretation to identify potential water sources. Finally, analyse the geophysical prospecting results, and drilling verification. The experience and lessons from the combined application of hydrogeological and geophysical surveys in prospecting groundwater can provide a valuable reference for future groundwater exploration in granite areas.

Keywords: hydrogeological, comprehensive geophysical methods, granite areas, groundwater prospecting

INTRODUCTION

Groundwater exploration has become a major concern especially due to depleting nature of the resources as erratic rainfall patterns in semiarid and hard rock terrain[1]. Groundwater usually found in soil pore spaces and fractures of rock formations is not uniformly distributed everywhere, with its occurrence manifesting a lot of variability from one geological formation[2]. There are several difficulties in the development of groundwater resources in hard granite rocks area are a result of a wide range of erratic variations of vital parameters such as fractures, joints, porosity, etc.[3, 4].

The southern Jiangxi region, was designated as poverty alleviation area by the ministry of natural resources. The region has a large rural population, a large base of poor people and a widely distributed. Some villages suffer from seasonal water shortages all year round, and domestic water is difficult to obtain. Water wells are shallow and the water quality is poor. The area suffers from year-round water shortages, shallow water wells, and

poor water quality, The problem of safe drinking water needs to be solved urgently. With the support of the China Geological Survey's and Southern Jiangxi Drinking Water Safety Project supports, hydrogeological and geophysical methods for groundwater exploration efforts in the region. The study project focuses on 20 water-deficient villages in southern Jiangxi, particularly in Ningdu, Yudu and Gan County, these areas are known for its large granite distribution.

This research aims to address the water scarcity by conducting groundwater exploration using hydrogeological surveys and comprehensive geophysical methods to identify potential groundwater sources in the granite-rich areas.

The study area is located in the area from Dongshanba Town to Dongshao Township in the north of Ningdu County, Ganzhou City. The geological overview of the work area and the location of the geophysical exploration area is shown in Figure 1.

Direction for groundwater exploration

On-site hydrogeological surveys were conducted in the four survey areas to clarify the water-seeking

directions in each survey area. See Table 1 for details.

Table 1 Hydrogeological conditions and groundwater prospecting directions

Survey area and number	Hydrogeological conditions	Water finding direction
① Vegetable Base in Tianying Village, Dongshao Township	The survey area is located in a northeast wide valley, with a flat terrain and a thick weathered granite crust. There is a northeast trending fault structure (F2) within the area, with well-developed joint fissures.	Mainly to find structural fissure water and granite weathering fissure water.
② Ganbei Village, Dongshanba Town	The survey area is located at the intersection of a northeast trending gully and a northwest trending gully, with developed northeast trending faults.	To investigate whether there are NNE trending faults in the gullies; to find structural fractures Water-based.
③ Dongshanba Town, LiaoYuanyuan Group	The survey area is located in a northeast oriented valley, with a width of less than 150m and a small catchment area, making it difficult to find water.	Investigate whether there are NE-trending faults in the gullies; to search for structural fissure water main.
④ Dongshanba Town Xiaoyuan Village	The terrain is flat, with northeast trending faults (F5) developed, and a fault valley is located 700m south of the target area.	Mainly to find structural fissure water and granite weathering fissure water.

Methods and Analysis of geophysical results

The layout of the survey lines and the direction of the running poles are shown in Figure 1. The joint profile method and electrical resistivity method were selected as the main geophysical methods for groundwater exploration, since it is fast and effective to this geophysical exploration work. Due to space limitations, this article will not elaborate on

(1) Dongshao Township Vegetable Base

Figure. 2 shows the results of the geophysical exploration of the Tianying Village, Dongshao Township. Figure. 2a is the joint profile curve the exact position of the point for the joint profile curve with polar distances $AO = BO = 150m$ is orthogonal. The differentiation of the Rb curve has an increasing trend at section 610-680, and it is inferred that the fault structure development zone is near this point. It is inferred that the anomaly is a reflection of the fault structure, and water exploration holes are arranged at profile 620, see Figure 2b. For drilled verification results please refer to Table 2 for details. It can be seen that the electrical resistivity 2D inversion results are in good agreement with the drilling exposure. The drilled borehole column aligns with the inversion results of geophysical exploration, highlighting the agreement between the geophysical exploration and the drilling results.

(2) Ganbei Village, Dongshanba Town

Figure 3 shows the results of geophysical exploration in Ganbei Village, Dongshanba Town. Figure 3a is the joint profile curve with pole distances $AO = BO = 110m$, at profile section 420, the Ra and Rb curves are characterized by orthogonal points which are inferred to reflect the

the principles of geophysical parameters used. As the geophysical results of survey areas ① and ④, ② and ③ are similar, only the geophysical results of survey areas ① and ② are listed and analyzed here.

fault structure. Combining the positions of the two intersection points on the profile, it can be inferred that the fault tends to the large direction near section 430 the joint profile curves of the pole distance show a "V"-shaped low-resistivity anomaly. It reflects the existence of the low-resistivity anomaly. It also shows a trend of inclining to the large point, further confirming the fault structure's existence. Through the 2D inversion of resistivity, the inversion results are shown in Fig. 3b from the figure, and the void of the fault structure can be seen. According to the morphological characteristics, it is inferred that the width of the fractured zone is about 30m and the inclination angle is about 70° , so drilled borehole (ZK) was arranged at section 420. Please refer to Table 2 for details.

Drilling verification

Drilling verification and pumping tests were carried out on the four boreholes as arranged in Table 2. Further analyze the geophysical results based on drilling data. survey area ① is located in a wide valley with relatively good water richness. There are fault structural zones in measurement areas ② and ③ that intersect with the geophysical survey lines at a large angle. There is a northeast trending

fault structure in survey area ④, with developed northeast trending faults in the valley and Fault zones were observed in some areas affecting water output, while others had good groundwater supply.

In 2019, the acceptance criteria for safe drinking

water in Ganzhou's poverty alleviation campaign were as follows: the per capita daily drinking water volume is more than 60 litres to meet the standard fully. Judging from the pumping test results, the standard requirements are generally met.

Table 2 Drilling results and pumping test

Measurement area number and name	Description of drilling lithology and water content	Pumping test and mining output suggestions
①Tianying Village Dongshao Township Vegetable Base	Drilling depth is 100.34 m. 0-8.9 m is the Quaternary alluvial layer, containing pore water with moderate water richness; 8.9-16.0 m is a strongly to moderately weathered granite; Granite structure at a depth of 16.0-100.34 m has developed fissures, containing fissure water with strong water abundance.	From October 8th to 11th, 2019, the depth decreased by 10.45m and the stable flow rate was 385 tons per day. It is suggested that the mining output should not exceed 308 tons/day, fully meeting the irrigation demand of the existing 150 vegetable base.
②Ganbei Village Dongshanba Town	Drilling depth is 84.18 m. 0-6.3 m is composed of Quaternary and fully weathered granite, containing a small amount of pore water; 6.30-14.0 m is moderately weathered granite with a small amount of pore water; 14.0-84.18 m is granite with well-developed structural types, quartz vein cementation, and weak water abundance.	From September 25th to 27th, 2019, the depth decreased by 39.44m and the stable flow rate was 12.12 tons/day. It is suggested that the mining output should not exceed 9.6 tons/day.
③Dongshanba Town Liao Yuanyuan Group	Drilling depth is 81.0 m. 0-4.8 m is completely weathered granite water with moderate water richness; 4.8-8.2 m is strongly to moderately weathered granite; 8.2-20.39m are fractured water in the breccia structure of granite, with weak water abundance; 20.39-81.00 m is a complete granite with few developed fractures and weak water abundance.	On October 1-3, 2019, the depth decreased by 28.02 m and the stable flow rate was 13.37 tons per day. There are about 150 people in Liaoyuantou Village who are short of water. It is suggested that the mining output should not exceed 10.96 tons/day.
④Dongshanba Town Xiaoyuan Village	The drilling depth is 99.8m. 0-6.1m Quaternary loose layer, containing pore water, with moderate water richness; 6.1-18.2 m are fully to moderately weathered granite with network fissure water and strong water richness; 18.2-99.8m is moderately to weakly weathered granite with well-developed joints and fissures.	From October 2 to 6, 2019, the drawdown of the hole is 10.5m, and the stable flow is 968.4t/d, which fully meets the drinking water demand of the village. It is recommended that the mining output should not exceed 775t/d.

Conclusion

Through the application research of hydrogeological and comprehensive geophysical exploration combined water exploration methods in the granite area of Ningdu County, Gannan city, the following conclusions have been drawn:

- (1) Hydrogeological survey and target area optimization should be carried out in the exploration of groundwater resources, the occurrence law and type of groundwater should be clarified, and the geophysical exploration methods, working parameters, data processing and data interpretation methods should be selected in a targeted manner, so as to achieve twice the result with half the effort.
- (2) When conducting groundwater exploration in areas with unclear geological information, comprehensive geophysical methods should be chosen as much as possible, and parallel comparative profiles should be set up in the direction of anomaly direction for verification, reducing the problem of multiple interpretations of water content anomalies by a single method or profile.
- (3) When tectonic fracture water is used as the main type of water searching, it should be determined whether the fault structure is a tensile fault or a compressive fault. For tensile faults, when there is no late or other material filling, its permeability and water content are strong, and the water output of borehole is usually large. The compressive faults are produced under the pressure of higher surrounding rock, and their tectonic fractures are mostly dense and small fractures, with poor permeability and water content, and the closer to the fault, the smaller the water output, which should

be paid attention to when looking for water in granite areas.

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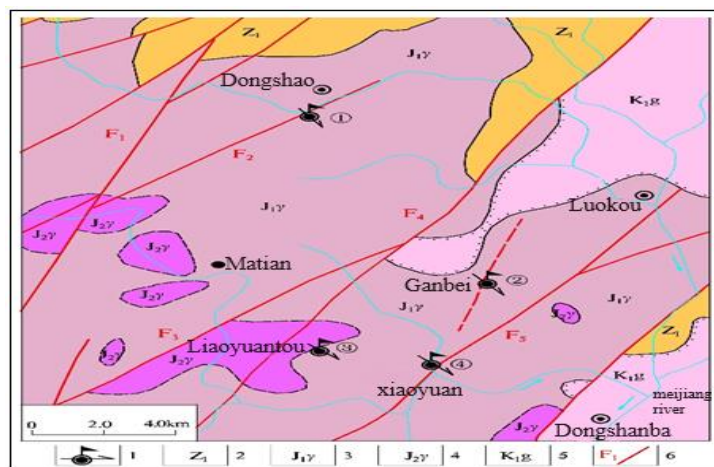


Figure.1 The brief map of General geology and geophysical location of survey area
 1- geophysical target area and survey line direction; 2- lower sinian series; 3- early jurassic granites; 4- middle jurassic granites; 5- early cretaceous ganjiang formation; 6 – fault.

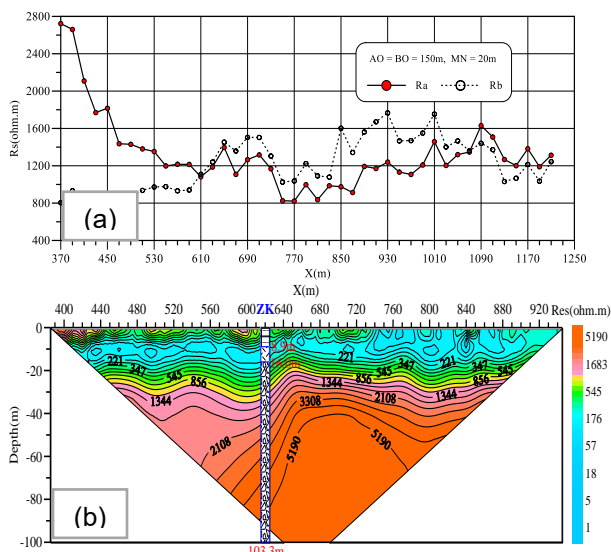


Figure. 2 Geophysical results for vegetable base of Tianying village, Dongshao township.
 a- joint apparent resistivity data for pole-dipole array with pole distance 150m, and b-inversion results for electrical resistivity method.

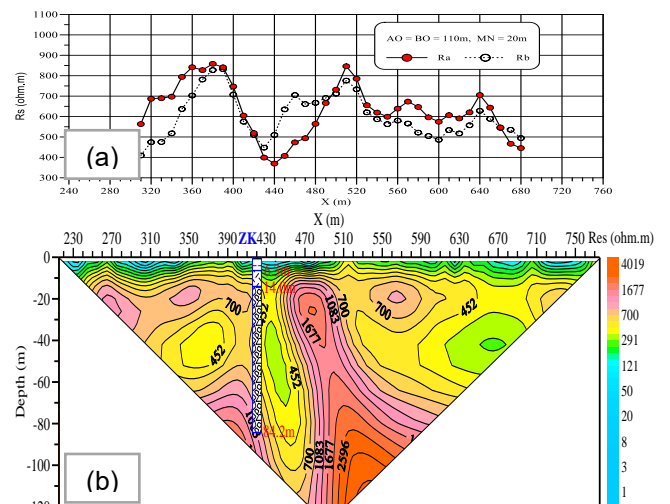


Figure.3 Geophysical results of Ganbei village, Dongshanba town.
 a- joint apparent resistivity data for pole-dipole array with pole distance 110m, and b- inversion results for electrical resistivity method.