Article ID: 1003 - 6326(2004)04 - 0829 - 04

Dual-frequency IP over Tanghuping Prospect①

Iraj Vosoughi-Niri, TANG Jing-tian
(School of Info-physics and Geomatics Engineering, Central South University, Changsha 410083, China)

Abstract: Gold mineralization in the Tanghuping Prospect was the target of the geophysical exploration. The mineralization shows close relation with geological structures and is accompanied by alteration. Sulfide concentrations in the altered zones were used to trace the mineralization by Induced Polarization(IP) method. Through laboratory and field measurements of some selected samples of the study area, their geophysical properties were studied carefully. After that by numerical calculation, a geophysical model was built. Six lines were designed to use dual-frequency IP sounding in the west of the surveyed area. Gradient, pole-dipole and reverse pole-dipole arrays were used to acquire the data. Interpretation of the processed data shows eight veins that demonstrate diverging and converging phenomena. Therefore east of the surveyed area is considered as most prosperous zone in the study area.

Key words: dual-frequency IP; numerical calculation; Tanghuping; geophysical model
CLC number: P 631.3 **Document code:** A

1 INTRODUCTION

The Tanghuping Prospect is located in Tanghuping Village, about 6 km southeast to Woxi Mine. Outcropped strata are mainly purplish-red Proterozoic slates of Madiyi Formation[1, 2]. Structures in the area are mostly composed of many faults in different sizes that have had activities for several times. These fault sets are distributed along the east-west and northeast directions[3, 4]. Mineralization of gold is mainly developed in the fractures, and accompanied by alterations such as silicification and pyritization[5, 6]. As concentrations of 0.5- 1.0 percent sulfides can give rise to appreciable IP effects, therefore IP is an effective and reliable method for investigating disseminated sulfide zones. Thus, it was employed to target the pyritized gold-bearing quartz veins in the study area.

2 ELECTRICAL PROPERTIES OF PROSPECT AND GEOPHYSICAL MODEL

Table 1 shows the testing results of electrical nature of typical ore samples in the Tanghuping Prospect. From Table 1, it can be seen that apparent resistivity of Proterozoic slates is about 1 000 Ω•m, Percent Frequency Effect (PFE) is about 1.0, and the feature of low polarization is shown. Relatively, apparent resistivities of silicified and pyritized slates and structural breccias are 1 500 - 2 000 Ω•m, and PFE is 3.0 - 5.0, feature of high resistivity and high polarization is displayed, which are different from the host rocks physically to a certain extent. Gold-bearing quartz veins are thin steep layers with uniform host rock lithology[2, 7]. Steep tilting sheets, well-distributed in half space, can be used to simulate the feature of such kind of veins. Fig. 1 shows a group of computer simulation results. While calculating using integral equation method, let us suppose that thickness of a buried vein is 10 m, its hanging wall's depth is 50 m, its dip angle 60°, resistivity is 1 500 Ωm, polarizability is 20%, and resistivity of the host rocks is 1 000 Ωm. The results indicate that apparent resistivity anomaly produced in this type of ore veins is not obvious, about 10%, while the PFE is clear. Therefore, we can use high-precision dual-frequency IP to survey and evaluate silicified and pyritized gold-bearing quartz veins in Tanghuping. In dual-frequency IP method not only the dual-frequency current is transmitted simultaneously but also the electric potential difference due to dual-frequency current is measured synchronously[8, 9]. Hence, three proper electrical arrays, gradient, pole-dipole, and reverse pole-dipole, were used to study the deposit.

3 SURVEYING, INTERPRETATION AND GEOLOGICAL EXPLANATION

3.1 Gradient array

Six lines were designed to apply dual-frequency IP sounding in the west of the surveyed area. In first step, gradient array was used in the work. Length

① **Foundation item:** Project financially was supported by Xiangxi Gold Mine Co.
Received date: 2003 - 10 - 15; **Accepted date:** 2003 - 11 - 10
Correspondence: Iraj Vosoughi-Niri, PhD; Tel: + 86-731-8831777; E-mail: ivosoughi@yahoo.com

Table 1 Measured results of electrical properties of typical rock samples of Tanghuping Prospect in laboratory and field

Rock type	Number of samples	PFE/%			Apparent resistivity/(Ω·m)		
		Measured in lab		Measured in field	Measured in lab		Measured in field
		Range of variance	Mode		Range of variance	Mode	
Grey, purplishred slates	17	1.0－2.4	1.2	0.8－1.0	397－1 857	1 047	800－1 600
Silicified and pyritized slates	8	3.3－7.0	5.4	3.0－5.0	700－2 198	1 534	1 600－2 000
Structural breccias	9	1.8－5.4	2.6	2.0－3.0	1 080－2 908	1 728	1 500－2 000

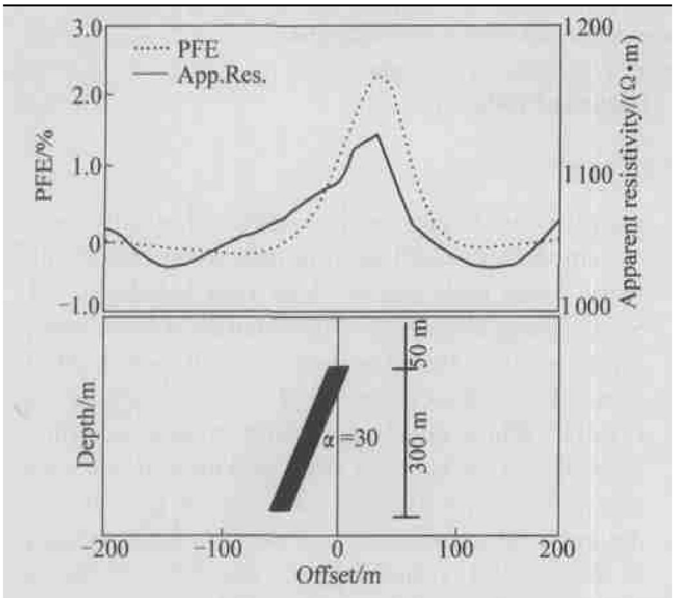

Fig. 1 Simulated gradient array over a model vein (width= 10 m, height= 316 m, length= ±∞) (not in scale) with its numerical calculation results. The model vein's resistivity and PFE are 1 500 Ω·m and 20% respectively, the same as the sampled ores in the prospect. Model host rocks' PFE and resistivity are 0% and 1 000 Ω·m respectively. Potential electrodes spacing is 10 m and current electrodes are placed in − 500 and + 500 m on the same surveying line. By using the implemented method the plotted curves show very clear PFE and apparent resistivity anomalies.

of current (AB) and potential (MN) electrodes are 300 and 10 m respectively. Fig. 2 shows PFE results on the surveyed lines. In the study area, theoretically, dual-frequency IP anomalies could be caused by different sources. Gold-bearing quartz veins show weak resistivity while their PFE is high. Water-containing breccia zones, mountain ridges and shear zones have low resistivity and low PFE. Well pyritized, water saturated, breccia zones and veins in mountain ridges show low resistivity and high PFE anomaly. Fig. 3 demonstrates combination of the PFE results with geological map of the area. It can be seen that:

1) There are eight veins in the prospect. On the whole, sloping to the north, their strike is NEE, and their dip angle varies from 60° to 75°. Generally, there is a vein diverging and converging phenomenon in the area. After diverging, veins gradually disappear while in converging cases, veins gradually close to each other and form rich mineralized zones at their intersections.

2) From Station 30 to 40 in Line 3, it is a converging zone. Here, the ore vein appears on the ground, where gold grade is about $(3-6)\times 10^{-6}$. It diverges and extends to Lines 2 and 4, then gradually disappears.

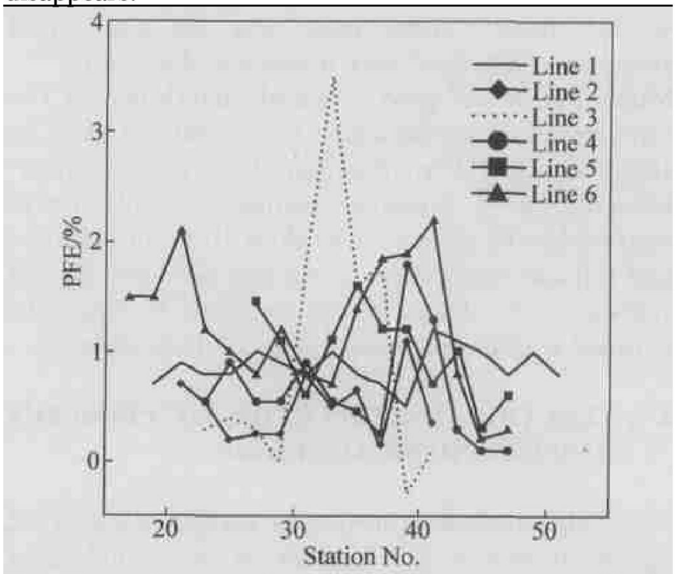

Fig. 2 PFE changes along all the six surveyed lines are shown. While Lines 3 to 6 show high anomalous PFE percentages, Lines 1 and 2 on the west of the prospect show minimum changes.

3) From Station 36 to 44 in Line 6, it is another converging zone of veins 4 and 5. It extends to Line 5 and disappears to west. It extends at least 100 m from Line 6 to the east.

4) Based on the above explanations and Fig. 3, it can be deduced that emphasis should be laid on Lines 3, 4, and east of Tanghuping.

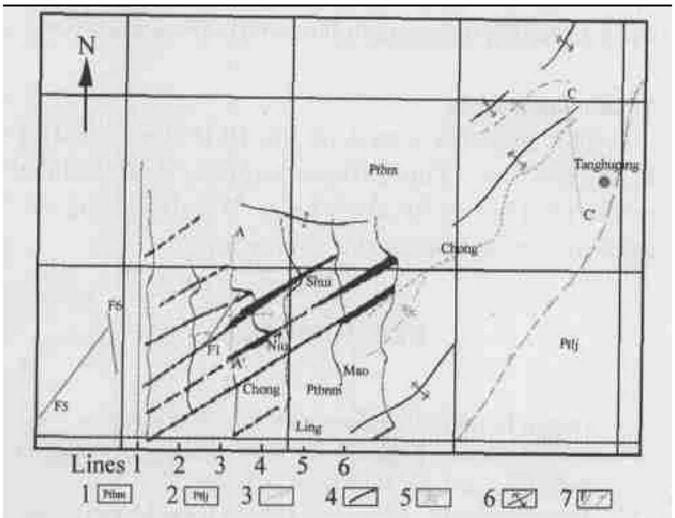

Fig. 3 Geological sketch map of the surveyed area. All the six surveyed lines and anomalous zones are demonstrated. 1. Ptbm —Madiyi Formation, 2. Ptlj —Lengjiaxi Group, 3. Ore veins outcrop, 4. Ore veins detected by IP, 5. Syncline, 6. Anticline, 7. Normal and reverse faults. Eight ore-veins, hosted by Madiyi Formation strata, were detected in the prospect. They are displaced by post-mineralized faults in some parts of the region.

3.2 Pole-dipole and reverse pole-dipole array

Following stage one operation, combination of pole-dipole and reverse pole-dipole arrays with two different spacing were used to study the two most prosperous Lines 3 and 4. Fig. 4 shows a combination result of both arrays' PFE curves in different spacings.

On the combined section curve of PFE in Line 3, a counter-crossing station of high polarization is displayed near Stations 32 and 36. Analyzing the area between the two points, we see the vein slopes towards the north. The result when dipoles spacing is 155 m (Fig. 4(b)) shows that the veins converge in depth and extends over 200 m. The combined section curve of Line 4 indicates that the vein extends little to the depth, not more than 150 m, and has no economical values.

Fig. 5 is the sounding curve of Station 36 in Line 3. In a plate-like structure, the sounding curve is not only related to underground electrical phenomena, but also to the implemented configuration. Results of experiments show that: on an upright non-polarized and high resistivity plate, when the dipole line is perpendicular to the plates strike, shape of the ρ_s curve is "G", while when it is parallel, there is no change on the ρ_s curve. But on the plate of high resistivity and high polarization, when the dipole line is parallel to the plate's strike, the shape of PFE curve is "K". In this case, by increasing the plate's slope, anomaly becomes stronger. When the dipole axis is perpendicular to line of strike, the shape of PFE curve is similar to a sphere, resembling a "G"[10]. Measuring PFE as the main geophysical parameter in the survey, dipole axis was configured parallel to local structures' line of strike.

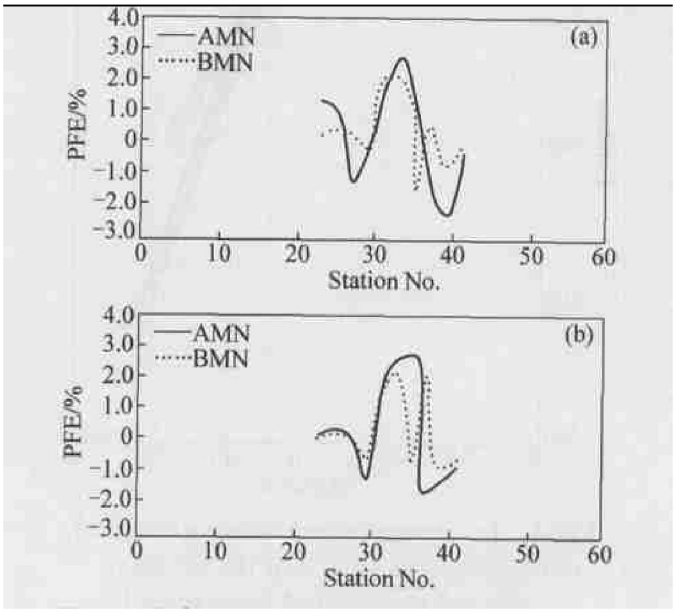

Fig. 4 Pole-dipole (AMN) and reverse pole-dipole (BMN) PFE curves with dipole spacing (a) AO= 105 m and (b) AO= 155 m on Line 3 in the Prospect. Potential electrodes (MN) spacing is 10 m. X axis is station number and Y axis is PFE percentage.

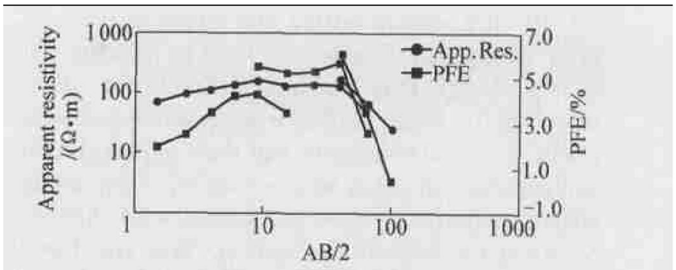

Fig. 5 Sounding curves at Station 36 of Line 3 at Prospect

Analyzing Fig. 5, it can be seen that when the AB dipole axis is parallel to the strike, the curve of apparent resistivity is almost a straight line with a little undulation. While among 10 and 60 m AB/2 spacing, PFE curve is KHK-type in general. Corresponding to two vein groups which converge at depth, the above is consistent with the result of the combined section. The two veins with 6 and 26 m thickness are buried at 6 and 35 m depth respectively at their start point. Eventually sounding results of all the sounding stations were used to draw the interpreted geological cross sections of the surveyed lines. Fig. 6 is interpreted geological cross section of Line 3 that shows detected veins and their attitude changes in shallow and depth.

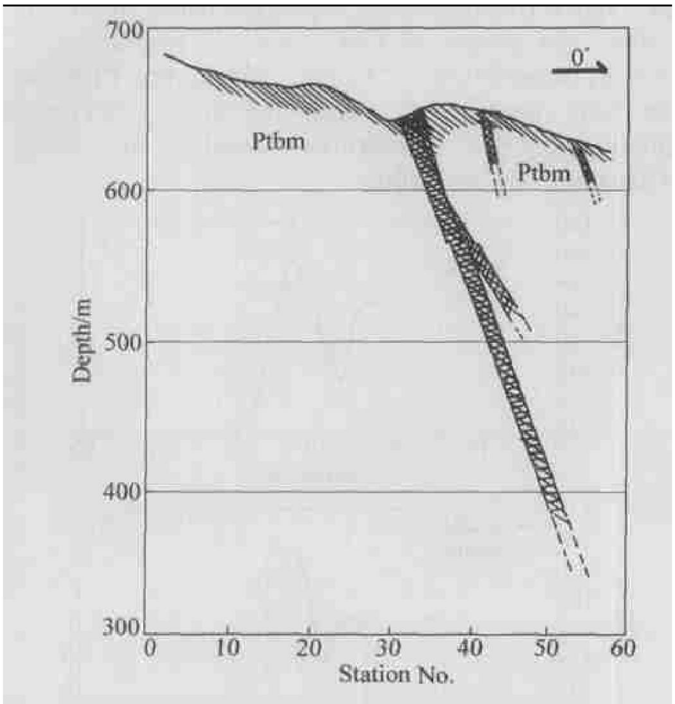

Fig. 6 Interpreted north-south geological cross-section of Line 3 in the prospect. Detected and mapped veins are all hosted by Madiyi Formation (Ptbm). Convergence of veins near the surface and their divergence at depth is clearly shown

4 CONCLUSIONS

By rock sample testing and numerical calculation, a geophysical model was built to be employed in the Tanghuping Prospect. Employing dual-frequency IP, eight gold-bearing quartz veins were found in the surveyed area and their mineralization and exploitation value were evaluated. This study shows while there are no economically feasible ore bodies in the west of the Line 3, there are sloped prosperous veins in the east. They are similar to the Woxi deposits' veins and more exploration work is highly recommended for their exploitation.

Acknowledgments

This paper is a part of the PhD thesis of Iraj Vosoughi-Niri. The authors express their thanks to the field crews for their help. We also thank A. Dalvean for reviewing the manuscript.

REFERENCES

[1] Hunan Bureau of Geology and Mineral Resources. Annals of Hunan Regional Geology. Beijing: Geological Publishing House, 1982. (in Chinese)

[2] Vosoughi-Niri I. Integrated Geoelectrical Methods over Woxi Gold Deposit[D]. Changsha: Central South University. 2003.

[3] HUANG J. Main Structural Geology Units of China[M]. Beijing: Geological Publishing House, 1994. (in Chinese)

[4] XIE Xiang-hong. Structural units division of Hunan and their Geophysical features[J]. Hunan Geology, 1992, 11(4): 334-342. (in Chinese)

[5] CAI C, Li Z. Gold minerals in China and the characteristics of their occurrences[A]. 14th Gen Meet Intern Miner Assoc[C]. Stanford (Calif), July 13-18, 1986.

[6] XI Xiao-shuan. On the structural characteristics and genesis of layer-parallel codes at Xiangxi gold mine[J]. Journal of Central South University of Technology, 1995, 26(Suppl. 4): 136-139. (in Chinese)

[7] NIU H. Geology of stratabound gold deposits in West Hunan[J]. Geology of Ore Deposits, 1992, 11(1): 65-75. (in Chinese)

[8] HE Ji-shan. Dual-Frequency IP[J]. Trans Nonferrous Met Soc China, 1993, 3(4): 1-10.

[9] Telford W M, Geldart L P, Sherif R E. Applied Geophysics[M]. 2nd Edition. London: Cambridge University Press, 1995.

[10] FU Liang-kui. Electrical Prospecting [M]. Beijing: Geological Publishing House, 1983. (in Chinese)

(Edited by ZHANG Zeng-rong)